Digitized by the Internet Archive
in 2009 with funding from
University of Toronto

http://www.archive.org/details/n1annalsentomolo03ento

QL
461
E579
V.3
NO.1
Biological
& Medical
Serials

STORAGE

PROPERTY
OF
TORONTO ENTOMOLOGICAL SOCIETY
OF ONTARIO
CANCELLED
No.....

Biological
& Medical
Serials

Volume III. Number 1.

LIBRARY
JUL 21 1950
UNIVERSITY OF TORONTO

ANNALS

OF

The Entomological Society of America

MARCH, 1910

EDITORIAL BOARD

J. H. COMSTOCK,
ITHACA, N. Y.

L. O. HOWARD,
WASHINGTON, D. C.

C. J. S. BETHUNE,
GUELPH, ONTARIO, CANADA.

W. M. WHEELER,
BOSTON, MASS.

C. W. JOHNSON,
BOSTON, MASS.

P. P. CALVERT,
PHILADELPHIA, PA.

V. L. KELLOGG,
STANFORD UNIV., CAL.

J. W. FOLSOM,
URBANA, ILLS.

HERBERT OSBORN, Managing Editor,
COLUMBUS, OHIO.

PUBLISHED QUARTERLY BY THE SOCIETY
COLUMBUS, OHIO

Entered as second class matter April 11, 1908, at the Post Office at Columbus, Ohio, under the Act of Congress of March 3, 1879.

Publications of the Entomological Society of America.

Annals, Vols. I and II, complete, each.....$3.00
Annals, Vols. I and II, Parts 1, 2 and 4, each..... 1.00
Annals, Vols. I and II, Part 3, each..... .50

REPRINTS

Proceedings of first three meetings; Constitution, By-Laws and List of Members..... .25

Wheeler, Wm. M.—Polymorphism of Ants..... .30

Osborn, Herbert—The Habits of Insects as a Factor in Classification..... .20

Severin, H. H. and Severin, H. C.—Anatomical and Histological Studies of the Female Reproductive Organs of the American-Saw fly, Cimbex Americana, Leach..... .25

Felt, E. P.—Some Problems in Nomenclature..... .10

Hammar, A. G.—On the Nervous System of the Larva of Corydalis cornuta L .25

Bradley, J. C.—A Case of Gregarious Sleeping Habits among Aculeate Hymenoptera..... .10

Davis, J. J.—Notes on the Life History of the Leafy Dimorph of the Box-elder Aphid, Chaitophorus negundinis Thos..... .10

Hambleton, J. C.—The Genus Corizus, with a Review of the North and Middle American Species..... .25

Girault, A. A.—Biological Notes on Colorado Potato Beetle..... .25

Girault, A. A.—A Monographic Catalogue of the Mymarid Genus Alaptus .25

Severin, H. H. and Severin, H. C.—Internal Organs of Reproduction of Male Saw-fly..... .15

Smith, C. P.—A Preliminary Study of the Araneæ Theraphosae of California .75

Davis, J. J.—Studies on Aphididae..... .20

Riley, W. A.—Muscle Attachment of Insects..... .15

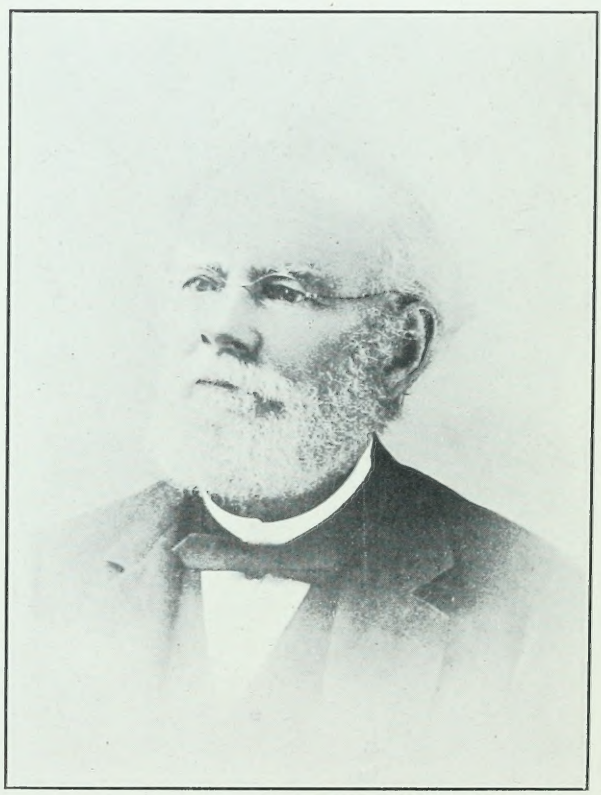
Needham, J. G.—Critical Notes on the Classification of the Corduliinae (Odonata)..... .15

Howard, L. O.—A Key to the Species of Prospaltella with Table of Hosts and Descriptions of Four New Species..... .15

Hood, J. D.—Two New Species of Idolothrips..... .10

Address

ANNALS ENTOMOLOGICAL SOCIETY OF AMERICA,
Biological Building, O. S. U., Columbus, Ohio



WM. H. EDWARDS

Plate I.

ANNALS

OF

The Entomological Society of America

Volume III MARCH, 1910 Number 1

MINUTES OF THE BOSTON MEETING.

The Fourth Annual Meeting of the Entomological Society of America was called to order by the President at 10:30 A. M., December the 30th, 1909, in the buildings of the Harvard Medical School in Brookline.

The President announced the deaths of the following Fellows and Members:

William Henry Edwards, Honorary Fellow, April 4, 1909.

Mark Vernon Slingerland, Fellow, March 11, 1909.

Braxton Honoré Guilbeau, January 16, 1909.

William Brodie, August 6, 1909.

H. M. S. Seib, August 28, 1908.

The minutes of the last meeting were accepted as printed in the ANNALS.

The President announced the appointment of the following committees:

Committee on Resolutions: Messrs. Satterthwait & Brues.

Committee on Nominations: Messrs. Gillette, C. W. Johnson and Burgess.

Auditing Committee: Messrs. Field, Johnson and Sanderson.

Committee to Draft Suitable Resolutions Concerning the Death of Mr. Edwards: Messrs. Newcomb, Wheeler and Field.

Committee to Draft Suitable Resolutions Concerning the Death of Professor Slingerland: Messrs. Comstock, MacGillivray and Riley.

The following report from the Executive Committee was read by the Secretary-Treasurer, and adopted, the constitutional amendments to be brought up at the next annual meeting.

Report of the Executive Committee,

December 30, 1909.

The following six persons were elected members in June:

E. W. Berger,
W. A. Thomas,
R. A. Cooley,
E. H. Smart,
V. I. Safro,
W. O. Strong.

Ten more members were elected at the meeting of the committee yesterday:

Miss E. A. Newell,
Mr. A. C. Lewis,
Mr. W. W. Chase,
Mr. S. F. Blumenfeld,
Mr. P. E. Smith,
Mr. T. C. Barber,
Mr. W. V. Reed,
Dr. C. G. Hewitt,
Mr. J. W. Hungate,
Mr. W. H. Shideler.

The following resignations have been accepted and memberships terminated:

Rev. G. Birkmann,
Mr. C. F. Groth,
Mr. G. H. Chadwick,
Mr. M. Rothke,
C. E. Brown,
A. Ellsworth,
E. C. Greene,
T. D. Jarvis,
J. M. Rankin,
C. Stevenson,
A. J. Meidt,
Mr. C. L. Pollard,
Miss A. M. Fielde,
Mr. F. M. Needham,
J. P. Baumberger,
J. P. Cockburn,
E. Gerstenhorn,
J. C. Huguennin,
R. E. Lea,
W. D. Richardson,
W. L. Tower,
A. F. Winn.

The Executive Committee proposes to the Society for its consideration the following amendments to the constitution to be brought up at the next annual meeting.

To amend Section I of Art. IV, by striking out the words "and a Secretary-Treasurer" and inserting in their place the words "a Secretary and a Treasurer; but these last two offices may be held by the same person, so that the section will read: Art. IV. Officers. The officers of this Society shall be a President, two Vice-Presidents, a Secretary and a Treasurer; but these two last offices may be held by the same person."

To amend Art. IV., Sec. 3, to read:

"SEC. 3. Councilor to the American Association. The President and preceding Past-President shall represent the Society upon the Council of the American Association for the Advancement of Science."

To amend Art. IV, Sec. 2, by striking out the word "who" and inserting after the words "additional members" the words "five of whom" and by inserting after the word "Society" the following: "and the sixth shall be, *ex officio*, the Managing Editor."

So that the Section will read:

"Art. IV, Sec. 2. The business of the Society not otherwise provided for shall be in the hands of an Executive Committee, consisting of the officers named in Section I, and of six additional members, five of whom shall be elected from the Fellows by the Society, and the sixth shall be *ex officio* the Managing Editor. Four members of the committee shall constitute a quorum."

The committee farther recommends an amendment to the proposed amendment to Art .V, by inserting at the end thereof the following: "Their term of office shall commence with the first of June following their election."

During the year a memorial drawn up by Mr. W. C. Wood regarding the tariff on insects and signed by the President and Secretary-Treasurer, was sent to the Honorable Sereno E. Payne. No action by Congress resulted.

CLASSIFIED EXPENDITURES

Notices, programs, etc. (Society)		$ 10.25	
Stationary (Society)	$ 24.61		
And Stamps	9.25		
Annals, postage and stamps for Annals	13.00	46.86	
Clerks and Stenographers (Society)	8.75		
(Annals)	8.00		
		16.75	
Printing Annals, 4 issues, 1000 copies each	$522.50		
12 Half-tone Inserts	55.00		
		577.50	
Engravings and electrotypes		61.62	
Express and Drayage (Annals)		14.74	
Reprints		138.15	
Total			$866.17
Balance on hand December 1, 1909			147.47
			$1013.64

Of the above total cash expenditures $43.61 were for the general expenses of the Society and the remaining $822.56 were for expenses connected with the ANNALS. In addition to the

total cash expenditures $866.17, there are debits on the ledgers to Society $54.00 and ANNALS $12.00, total $66.00, representing cancelled subscriptions, and the offsetting of dues of deceased and dropped members, etc.

CASH RECEIPTS.

Balance on Hand Dec. 15, 1908	$108.44	
Receipts from members (excluding 10 cents refunded to Brimley)	723.25	
Subscription from non-Members (excluding $3.00 returned)	137.10	
Sale of Reprints and from Excess Engraving Charges Refunded	44.75	
		$1013.54

ASSETS.

Balance from 1908.	From Managing Editor	10.67	
	From Society and Annals	264.27	
			$ 274.94
Annals:	Subscriptions from non-members.*	141.10	
	Subscriptions from members	320.00	
	Sale of Reprints and Refunded Excess Engraving Charges	44.75	
			505.85
Society.	Dues from members	487.00	
	Life membership fees	100.00	
	Gift from S. Henshaw	6.00	
			593.00
	Total Assets		$1373.79

From this sum $66.00 debits representing subscriptions cancelled and the offsetting of dues of deceased and dropped members, etc., should be deducted, leaving $1,307.79 as the substantial assets at the close of the year, and leaving a balance of $339.55 unpaid assets to carry forward.

The Society had no liabilities at the end of the year except $48.30 paid by members for dues and subscriptions for 1910.

Nov. 30, 1909.	Unpaid assets		$339.55
Nov. 30, 1909.	Cash on hand	$147.47	
	Less Liabilities	48.30	
	Cash Assets		99.17
	Total Assets forward		$438.72

This shows a healthy increase in the total assets carried forward of $162.78 over 1908. In comparison of the accounts with 1908, it must be remembered that that year included the expenses of but three issues of the ANNALS, while the present accounts include four issues, or one full volume. However, there are about 75 members who are now two years in arrears, having paid only

* Foot-note. The Report of the Managing Editor does not show whether there are unpaid subscriptions which would increase this sum.

the one year's fee when they were first elected or became Charter members. In all probability, many of them will eventually have to be dropped for the non-payment of dues, so that somewhere up to $150.00 of the present uncollected assets can not be counted on as materializing.

The appended resolution on the death of Professor Slingerland was read and adopted.

The following papers were read:

F. M. Webster: A Predaceous Mite, *Pediculoides ventricosus* producing a Dermatitis in Man. (Read by Prof. Osborn).

R. Matheson: Remarks on the External Anatomy of the Haliplidae.

Miss A. H. Morgan: Some Correlations of May-fly Structure and Habit.

C. J. Triggerson: The Life-cycle of the Oak Hedgehog Gall-fly (Acraspis erinacei).

H. H. Lyman: An improved Drawer for Insect Cabinets and a New Substance for Lining Them.

A. D. Macgillivray: The Female Reproductive Organs of *Corydalis cornuta*.

The Managing Editor gave a brief report for the Editorial Board; summarizing the work of the year. Four numbers of the Annals have been issued with nearly 300 pages of text and twenty-nine plates. The list of outside subscriptions, has been increased and includes many of the principal libraries. Most of these subscriptions are continuous and we may expect further additions as the publication becomes known. Members who are so located that they can influence librarians in placing the Annals on their permanent periodical list, can assist the growth of the publication by effort in this direction. Moved and carried that the report be accepted.

The Society then adjourned till 2 p. m.

At that time, the President, in calling the meeting to order, spoke of the approaching first International Congress of Entomology at Brussels, Belgium. It was suggested that delegates from this Society be appointed, and there being no objection, this was referred to the Executive Committee.

The following papers were read:

W. M. Wheeler: On the Effects of Parasitic and Other Kinds of Castration in Insects.

W. L. W. Field: The Offspring of a Captured Female of *Basilarchia proserpina.* To be published in Psyche.

F. L. Washburn: A Jumping Seed-gall on the Burr Oak.

The Society then adjourned to inspect the entomological exhibition, which was in conjunction with and under the auspices of the Cambridge Entomological Club.

At 8 P. M., the Annual Public Address was given by Dr. John B. Smith, in the lecture hall of the Boston Society of Natural History. "Insects and Entomologists: Their Relations to the Community at Large."

An abstract of this address appears elsewhere in this number of the Annals.

At 10 A. M., December 31st, the Society was again called to order by the President, Dr. Skinner.

The appended resolutions on the death of Mr. Edwards were read by Dr. Wheeler and adopted.

The President remarked upon the travels of Mr. Edwards on the Amazon River, and the high character of the volume descriptive of that trip, which Mr. Edwards had published, many years ago, under the title "Voyage up the Amazon."

Mr. C. T. Brues read a paper entitled, "Some Notes on the Geological History of the Parasitic Hymenoptera."

The Nominating Committee made its report and the Secretary was directed by vote of the Society to cast a ballot for the entire list thus placed in nomination.

The officers thus elected were as follows:

President, John B. Smith.
First Vice-President, Dr. S. A. Forbes.
Second Vice-President, Prof. V. L. Kellogg.
Secretary-Treasurer, Mr. C. R. Crosby.

Additional Members of the Executive Committee:

Prof. J. H. Comstock,	Prof. J. M. Aldrich
Dr. W. M. Wheeler,	Rev. Prof. C. J. S. Bethune,
Mr. E. A. Schwarz,	Prof. Lawrence Bruner.

Member of Committee on Nomenclature to serve three years:

Prof. T. D. A. Cockerell (to succeed himself).

The following report from the Auditing Committee was read and accepted.

REPORT OF THE AUDITING COMMITTEE.

BOSTON, MASS., Dec. 31, 1909.

To the Entomological Society of America:

Your Auditing Committee has examined the books of the Treasurer and the Managing Editor of the Annals and find them in satisfactory condition.

Your committee recommends that the manner of keeping the financial records of the Society be referred to the Executive Committee to determine the future policy.

Your committee wishes to express the thanks of the Society to the Treasurer, J. Chester Bradley, for the painstaking manner in which the accounts of the Society have been kept.

(Signed) E. D. SANDERSON,
C. W. JOHNSON,
For the Auditing Committee.

The following report was read and adopted:

REPORT OF THE COMMITTEE ON RESOLUTIONS.

The Resolution Committee begs to submit the following resolutions:

Resolved, That we extend thanks to the local committee on arrangements, the Cambridge Entomological Club, the Boston Society of Natural History, the corporation of Harvard University and the faculty of the Harvard Medical School for their many privileges and courtesies accorded us.

Resolved, That the editorial management of the ANNALS of the Entomological Society of America, especially Professor Herbert Osborn, be highly commended for the excellent standard which they have maintained in the publication.

Resolved, That an expression of thanks be extended to Dr. John B. Smith for his admirable public address delivered in the hall of the Boston Society of Natural History.

Resolved, That we also express our appreciation of the untiring work of our Secretary, Mr. J. Chester Bradley.

(Signed) C. T. BRUES,
A. F. SATTERTHWAIT.

The other members of the Committee on Nomeclature being absent, Dr. Felt stated that owing to the prolonged illness of one member of the committee and the somewhat extended absence

from the Country of another, it had been impossible for the committee to formulate any conclusions which could be reported upon at the present time.

The report of the Committee on Nomenclature made to the Baltimore Meeting and printed in the ANNALS for 1909 was read and adopted, with the provision that the Society express itself as standing with the majority of the Committee in Section V.

Mr. Brues suggested that Professor Felt submit a list of names of Gall Insects that he thought could be accepted as standard.

Mr. Sanderson moved that the request from Dr. Stiles for the preparation of a list of one hundred important names to be adopted by the Congress of Zoology as standard be referred to the Executive Committee. This motion carried.

The following amendment to the constitution proposed at the Baltimore Meeting, was read:

"Art. V, Sec. 3, to omit the following: "All officers, Secretary-Treasurer excepted, and all additional members of the Executive Committee shall be chosen from the list of Fellows. Provided, etc." The Secretary, in accordance with the recommendation of the Executive Committee moved to amend the amendment by adding the words at the end of the section: "Their term of office shall commence with the first of June following their election." Amendment to the amendment and original amendment carried, so that the Section now reads.

"Article V, Sec. 3. Election of officers. All officers shall be elected by ballot at the annual meeting for the term of one year and shall be eligible for re-election. Their term of office shall commence with the first of June following their election.

The Secretary was instructed to take a mail vote of all members and Fellows of the Society as to whether the present arrangement for separate dues and subscriptions to the ANNALS should remain in force, or whether they should be combined into a single membership fee of two dollars with the provisions that all members should receive without further expense the publications of the Society.

Prof. Sanderson suggested the adoption of a uniform style of button for both the entomological Societies meeting during Convocation Week. Referred to the officers with power.

The following papers were read:

J. C. Bradley: The Plaiting of the Wings of Hymenoptera.

T. J. Headlee: An Apparatus for the Determination of Optimums of Temperature and Moisture for Insects.

A. D. MacGillivray: The Radial Sector in *Phlebatrophia mathesoni*.

W. T. M. Forbes: A Structural Study of Some Caterpillars.

A. G. Hammar: Notes on the Life-History of *Fidiobia flavipes* Ashmead, an Egg Parasite of the Grape Root-Worm *Fidia viticida* Walsh.

In the absence of the authors the following papers were read by title only:

C. R. Crosby: Some Observations by the late Professor Slingerland and the Speaker on the Life-history of *Heterocordylus malinus* Reut.

M. J. Elrod: The Blackfoot Glacier as an Entomological Burying Place.

J. J. Davis: *Chaitophorus populifoliae* Fitch versus *Chaitophorus populifoliae* Oestlund.

L. Haseman: The Life-history of a Species of Psychodidae.

The Society then adjourned, to meet during Convocation Week of 1910 in Minneapolis.

J. Chester Bradley, *Secretary-Treasurer.*

RESOLUTIONS

On the Death of William H. Edwards.

Whereas, By the death of William H. Edwards the Entomological Society of America has lost one of the most illustrious of its Honorary Fellows, and

Whereas, Mr. Edwards, through his magnificent and epoch-making contributions to our knowledge of North American Lepidoptera was widely known as an investigator and author of the first rank; therefore, be it

Resolved, That this Society express, through these resolutions, its grief at this loss to the scientific world, and be it further

Resolved, That these resolutions be recorded in the Annals of the Society, and that the Secretary be instructed to send a copy of the same to the bereaved family of the eminent entomologist.

(Signed) H. H. Newcomb,
W. M. Wheeler,
W. L. W. Field.

MARK VERNON SLINGERLAND

RESOLUTIONS

On the Death of Professor M. V. Slingerland.

Mark Vernon Slingerland, naturalist, economic entomologist, Fellow of this Society, died at his home in Ithaca, N. Y., March 11, 1909. His death is a serious loss to the world of natural science. As a student, his career was marked by earnestness, courage and industry. As a teacher he was direct and forceful. As an investigator he was conscientious, unbiased, persevering and accurate, and his authority and leadership as an economic entomologist received unquestioned recognition.

His memory is cherished as that of a man whose life, though short, stands as a notable example of one who gave his years unselfishly and devotedly to the discovery of useful truths in the realm of natural history in their relation to the economy of plant and animal life. We, his colleagues, give expression to our sorrow in the loss of a friend and fellow worker.

(Signed) J. H. Comstock,
A. D. MacGillivray,
William A. Riley,
Committee.

INSECTS AND ENTOMOLOGISTS:

Their Relations to the Community at Large.

By John B. Smith, Sc. D.

*(Abstract)**

The importance of insects in their relation to the community at large has only become recognized during recent years, and the work of the entomologist is only now receiving the appreciation it merits. Entomologists in the sense used in the address include systematists, students of life histories and ecology and collectors; but not those studying only anatomy or histology or insects purely as hosts for disease-producing organisms.

Insects are injurious to man directly, as parasites, or as predatory forms attacking him, *e. g.*, lice in the one case, biting flies in the other. Incidentally he may be harmed by urticating larvæ or such as shed barbed hair, like the brown-tail caterpillars.

Insects are further injurious as carriers of, and intermediate hosts for, disease-producing organisms: two totally different processes for, in the first case, the insect has no necessary relation to the disease, *e. g.*, the house-fly to typhoid fever, while in the second the insect is a fellow sufferer, and the disease organism requires both man and insect to complete its life cycle, as in the case of the Plasmodia causing malarial diseases. The relation of mosquitoes to fevers, of flea to plague, and of Tsetse flies to the sleeping sickness was illustrated, and it was stated that if all dipterous insects, including fleas, could be at once eliminated, mankind would be at once freed from malarial, yellow, dengue, jungle, and several other kinds of tropical fevers, the bubonic plague, sleeping sickness, filariasis, several forms of eye diseases, certain ulcerating sores of tropical countries, and we would reduce to a minimum enteric fevers of all kinds, lessen the death rate from tuberculosis and pulmonary troubles, and probably modify or lessen leprosy and kindred diseases.

* This address was delivered before the Entomological Society of America and its friends on the evening of December 30th, 1909. It was a popular presentation of the subject, profusely illustrated by lantern slides, and not suitable as a whole for publication in a Scientific Journal.

All domesticated animals and birds suffer from insect attack and parasites. Lice, bots, horse and stable flies, fleas and the like, and many animal diseases are carried by insects and their allies the ticks. Here also the *Diptera* contribute the bulk of the dangerous and troublesome species, and to our horses, cattle and sheep the elimination of all flies would be as great a boon as to man himself.

Insects also live with man as messmates, preying on his stored products or acting as scavengers in his dwelling, and all the main orders are represented in this heading. They are further injurious by feeding upon the crops grown by him, the annual losses figuring up to enormous sums—estimated at $1,500,000,000 for the United States alone. All parts of the plants above and below ground, outside and inside are infested, and all kinds of plants are attacked.

Many insects have been introduced from foreign countries and some have profoundly influenced our agricultural methods. The San José Scale has revolutionized fruit culture in the eastern United States and, incidentally, has made more positions for entomologists and stimulated more interest in entomological work, than all other species combined:—in which respects it is not an unmitigated pest.

There is, however, another side to this shield and there are also insects directly and indirectly beneficial. Bee products are of great value, and silk products are enormously so. Some insects are used in medicine, a very few for food, and a few also in the arts.

The chief value to man, of insects, is as pollenizers to plants, and many plants are entirely dependent upon them for their continued existence. Pollenizers are found among the *Coleoptera*, *Lepidoptera*, *Diptera*, and, pre-eminently, the *Hymenoptera*.

Portraits were shown, and brief notes were given of Say, Melsheimer, Haldeman, LeConte, Horn, Abbot, Morris, Grote, W. H. and Henry Edwards, Hulst, Strecker, Clemens, Hagen, Osten-Sacken, Loew, Ashmead, Packard, Scudder, Harris, Glover, Fitch, Walsh, LeBaron, Riley, Lintner and Fletcher. A few collectors and founders of early societies were also referred to, Akhurst and Schaupp of Brooklyn, the latter one of the founders of the Brooklyn Entomological Society, and Feldman, of Philadelphia, ancestor of three generations of Coleopterists—the Wenzels—after whom the Feldman Social was named. Pictures of field

meetings of the New York, Brooklyn, Newark and Philadelphia Societies in New Jersey were also shown and the address thus summarized.

" * * * insects are a factor of very great importance in the community, first, because of their injuries, direct and indirect; second, because of their benefits, also direct and indirect, and millions of dollars annually are involved on both sides of the ledger."

"The entomologist who studies these insects, determines which are harmful and which are beneficial, who works out their life histories and habits and who determines methods of controlling those that are harmful and improving those that are beneficial, is a worker of high importance to the community and deserving of every possible aid and assistance.'

A PREDACEOUS AND SUPPOSEDLY BENEFICIAL MITE, PEDICULOIDES, BECOMES NOXIOUS TO MAN.

By F. M. Webster,
Bureau of Entomology, Washington, D. C.

Introduction.

Attacks of mites upon humans are by no means new, various instances of this character having been observed in Europe and recorded in various English and Continental publications both entomological and medical. In this country, up to very recently, except in the case of the itch mite, *Sarcoptides psoriques* Megn., these have all been grouped under the name "chigger," which is evidently a corruption of "chigoe," a tropical species, *Sarcopsylla penetrans* L., which is not a mite at all, but a flea. Thus it has come about that people walking during summer in grassy or weedy places or in woodlands are very often attacked by "chiggers" and suffer serious inconvenience and much pain on account of attacks of what are probably the larvae of several species of mites; notably the Trombidiums, just which one or how many is not at present known.

The mite involved in the two epidemics of dermatitis in the United States, to which this paper especially relates, is quite certainly the same as the one discovered by myself in 1882 and determined for me by Mons. Jules Lichtenstein of Montpellier, France, as *Heteropus ventricosus*, Plate III, figs. 1, 3, and since known in this country as *Pediculoides ventricosus* Newport. Huber has since made this species a synonym of *Pediculoides tritici* Lagreze-Fossat, to which Moniez credits a large number of instances of mites attacking man in Europe.

Mites attacking man in Europe and other countries.

In a publication relating to parasitology, both animal and vegetable, by R. Moniez,[1] quite a number of recorded instances have been brought together, some of them it is quite probable, involving the species to which this paper relates. Moniez is, however, vague and indefinite, and while crediting a large number of attacks of mites upon man to *Pediculoides tritici*, the fol-

1. Traite de Parasitologi Animale et Vegetal, Applique a la Medicine, Paris, 1896.

lowing statements made by him will most assuredly not apply to our American species, *P. ventricosus*, and if these food habits exist in *P. tritici*, this fact alone would separate the two species. On page 463 Moniez makes these statements:

"It appears certain that the octopod nymphs can only undergo evolution if they have at their disposition a liquid nourishment; they must attach themselves either upon some vegetable, or, in default of this, on some animal. In the case of wheat, they develop upon the larvae of insects that live at the expense of the grain. When the nymphs are famished, they will throw themselves upon workmen carrying wheat and attack the skin.

"Amerling, in Bohemia, did not find the mites in company with parasitic insects; they can live on the grain.

"When the cereals become dry, the mites attack animal life. They are forced to quit the vegetable kingdom for the animal. In this respect they act as do the Ixodes."

From the foregoing one is led to suspect that the obscurities surrounding the identity of man-attacking mites is scarcely less dense in Europe than it is in this country.

According to the observations of Lagreze[2] in 1849, in Espalais, France, a number of men engaged in carrying sacks of wheat experienced violent itching immediately thereafter. This wheat was sent to Bordeaux and Moissac where workmen in unloading the cargo were attacked in apparently the same manner. In the latter instance the men refused to work on account of the severe itching which immediately developed on the chest, arms, face and shoulders. In the case of a majority of the workmen this irritation of the skin was followed by an eruption of pimples more or less inflamed, some of which contained a serum. Later, experts who examined this grain reported the presence of numerous mites in the wheat and after this had been washed and dried in the sun, the workmen who handled it were not affected. The mite involved in this trouble is now known as *Pediculoides tritici*.

In 1867, Robin[3], in the name of M. Rouyer, communicated to the Society of Biology some observations on a cutaneous disease observed epidemically in a large number of communities of the department l'Indre. The peasants engaged in gathering the

2. (Lagreze Fossat et Montane, "Sur, la Mite du Ble." Rec. Agronomique de la So. de sciences agric. et bellesletters de Tarnet-Garome, t. XXXII, 1851).

3. Robin, C. R. des seances at memoires de la Soc. de biologie, 4th series, t. IV, 1867, page 178.)

wheat after the long rains of summer, developed an itching eruption on all exposed parts of the body.

May 1, 1872, a baker in the canton of Créon received a number of sacks of wheat from Bordeaux. Five men who were engaged in carrying these sacks promptly developed severe itching on the back, shoulders and arms, followed by an eruption of somewhat pointed red pimples. Fear seized the patients and their families, who thought themselves poisoned, but experts examining this wheat determined the cause of the trouble to be what is now known as *Pediculoides tritici*. The condition caused by this mite has been given the name of "grain fever."

In 1875, Targioni-Tozzetti[4] reported an eruption produced in a laborer who had carried sacks of wheat.

In 1879, Geber[5] observed in Lower Hungary an eruptive epidemic coming from barley. It appears that in the first days of the month of June, barley which was shipped from Lower Hungary, in sacks, was being unloaded at a railway station. After being engaged in this work for a few minutes, these laborers were attacked by a violent itching and burning and to such a degree did this become annoying and painful that it was with great difficulty that they were induced to continue their work. Geber desiring to obtain farther information, visited the railway station in question about ten days after and examined the laborers who had been attacked.

In order to carry out an experiment of his own, Geber employed an idiot to carry a sack of barley precisely as the laborers had done. The idiot also began unconsciously to scratch and immediately an eruption somewhat like nettle rash attacked him. It was observed at the time the laborers were handling these sacks of barley a yellowish-brown powder of considerable quantity fell out of the sacks and this circumstance turned the attention of the officials to the barley. Upon a small part of this powder being brought under a microscope the presence of both living and dead mites was revealed.

The illustrations of Geber's paper are two figures, figure 2 representing with reasonable accuracy what might have been a

4. Targioni-Tozzetti, Relazione intorno ai lavori della Statione di Entomologie agraria di Firenze per l'anno, 1876, Annali, dell Agricultura, t. I, 1878.

5. Geber, Entzundliche Prozesse der Haut, durch eine bis jetzt. nicht bestimmute Milbe Varursacht; Wiener Med. Presse, Vol. 20, 1879, et V. Ziemssen's Handbunchd, spec. Pathol. u Therapie, t. XIV, Handbuch, d. Hautkrank, 2, 1884, page 412.

female of *Pediculoides ventricosus*, at a stage of her development when these mites are most abundant in grain and straw, that is to say they had not yet commenced to become gravid. After making drawings of the ventral surface, Geber instead of turning this same individual over and making a drawing of the reverse or dorsal side took for this purpose what he presumed to be another mite of the same species. The facts are that in all probability the second mite was a male, as in speaking of the striking agreement between the two individuals, he says "it remains to be noted only that the individuals shown by figure 2 were very rare, only here and there were they to be found and they were easily recognized by their peculiar form." In view of this it would seem quite probable that the mite involved in the eruption recorded by him might have been what we in America know as *Pediculoides ventricosus*.

In July 1882, Koller[6] records a case where 36 workmen in Budapest were engaged in unloading sacks of barley coming from Roumania and were seized within a half hour by an intense itching, increasing in intensity during the several succeeding days. Vesicles, the largest of which were the size of a millet seed, appeared on inflamed bases on the neck, chest and other portions of the bodies of these laborers. Koller states in this connection that several years previously he had observed a similar malady contracted after unloading sacks of wheat from a boat.

Prof. Howath found a mite in the wheat which completely resembled that described by Robin, and several years prior to this, similar observations had been made on the banks of the Theiss, and in this case there was no other way to avoid the trouble except to submerge the boat with its cargo. At the same time that Koller observed this case, trouble was observed at Cologne with wheat coming from Russia.

Flemming[7] in 1884 published the results of similar observations upon workmen in Klausenburg, who unloaded wheat imported from Russia and were suddenly seized with a skin eruption.

If we compare these records from different parts of Europe and involving other adjacent countries as well, we will notice the similarity between these epidemics of a dermatitis and those

6. Koller, G. Ein Getreide-Milbe als Krankheitserregerin. Analysed in Biolog. Centralbi, t. III, 1884, page 127.

7. Flemming, J. Ueber eine Geschlechtsreife Form der ala Tarsonemus beschrieben Thiere, Zeitschr. f. Naturwissensch B. LVII, 1884, page 472, pl. 2.

occurring in America as recorded in the following pages. It would however, be too much to say that in all of these cases *Pediculoides ventricosus* was the species involved; but in view of the fact that the Angoumois grain moth, *Sitotroga cerealella*, Plate III, fig. 2, frequently becomes even more of a grain pest in those countries than it does here in America, one cannot but suspect that either the same or a closely allied species of mite is responsible for these attacks upon man. Mr. W. D. Hunter tells me that in Mexico he was warned not to allow the mites to get upon the hands of himself or his associates in his attempts to artificially introduce them into cotton fields attacked by the weevil, thus showing that its effect on man was not unknown there. Quite recently the writer has been informed that precisely similar effects have been experienced in New York City by men in handling peas from Italy, infested by *Bruchus* larvae, on which *Pediculoides* were observed to be parasitic.

Pediculoides ventricosus was described in 1853, and *P. tritici* Lag.–Fos was described in 1851. Huber[8] has made the former species a synonym of the latter, which, if sustained would throw nearly or quite all of the epidemics of dermatitis recorded to the credit of the one species and this would be known as *Pediculoides tritici* Lagreze–Fossat.

In Zur Morphologie und Ontogenie der Acariden[9], Dr. Enzio Reuter cites *P. ventricosus* as a good species but makes no mention of *P. tritici*.

The Mite Beneficial in America.

So far as I have been able to determine, the first published record of the occurrence of this mite in America was by myself, and was included in a paper printed in the Twelfth Report of the State Entomologist of Illinois, for the year 1882, pages 150–151. While assistant to State Entomologist Dr. S. A. Forbes, I was directed to investigate serious injuries to stored grain by the Angoumois grain moth (*Sitotroga cerealella*) in southern Illinois, where Messrs. Halliday Bros., of Cairo, extensive growers and shippers of wheat, were at that time experiencing considerable trouble from the ravages of this grain moth, not only in their grain elevators but also, in barges loaded with wheat to be shipped by river to New Orleans and thence exported by steamer.

8. Bibliographie der klinischen Entomologie (Hexapoden, Acacrinan.) von Med-Rath Dr. J. Ch. Huber, Jena, 1899.

9. Acta Societatis Scientiarum Fennicae. Tom. XXXVI, No. 4, pp. 185 and 195, 1909.

It was while making these investigations, that this mite was discovered attacking the larvae of the grain moth. As the original publication containing my observations is becoming more and more difficult to obtain, that portion of my paper relating to the occurrence of this mite is given herewith in full.

Pediculoides (*Heteropus*) *ventricosus*, Newport. About the 12th of October, 1882, a sack of wheat infested with larvae of the grain moth was received from Southern Illinois, which, for want of time, was put aside for future inspection. On the 13th of November, while examining the grains containing larvae, I noticed in a lot of fifty, three in which the worms were dead, and on them were numbers of globular, yellow objects, which proved to be a species of mite *Pediculoides* (*Heteropus*) *ventricosus*, Newport. Knowing nothing of the predaceous habits of these mites, and the limited literature at hand throwing little light upon the matter, I did not pay much attention to the fact of their occurrence, until the 12th of December, when upon examining one hundred grains with respect to the effect of heat on the larva, I found fourteen of the latter infested by these mites.

In the meantime I had learned that this mite was known to be of predaceous habit, in both England and France, (having been first discovered by Newport, in 1849, in the nests of *Anthophora retusa*, collected at Gravesend, England,) and afterwards described by him under its present name. It had also been found in France, in 1868, by Jules Lichtenstein, of Montpelier, and described by him under the name of *Physogaster larvarum*. This gentleman found it in his breeding cages, which it so completely overran that, as he informs me, he could not for six months breed a single specimen of Hymenoptera, of Buprestidae, or Cerambycidae, or of some Lepidoptera. If it has been found by any other persons than these, or in any other parts of the world, previous to its discovery here by me, I have not been able to find the fact recorded.

On December 31st and January 1st, I examined one hundred infested grains of this wheat, which had been continually kept in the laboratory since it was received, and found thirty-two per cent. of the worms dead, infested by the mites.

While making these examinations I frequently threw the grains containing infested larvae into a shallow glass dish, where they remained on my table until the warm weather during the latter part of February, when the temperature of the laboratory at night was much higher than it had been during the previous cold weather. The effect of the change was soon plainly to be seen. The contents of the dish began to swarm with newly developed mites, and a larva dropped into their midst was immediately attacked, and after that its life was of short duration. Larvae placed at some distance from the dish suffered a like infection.

To test the matter I placed near the dish some weeds, in the pith of which some larvae were hibernating, and in two days the mites had found and destroyed them. These young mites when first noticed are

very minute, of elongate form, and extremely active, running about in search of larvae; and when one is found they immediately puncture the skin and suck the juices.

In a day or two the posterior segments of the abdomen begin to enlarge and this process continues until the inflated, bladder-like abdomen becomes ten or even twenty times the size of the cephalothorax. Plate III, Fig. 3.

During this time they have gradually lost their ambulatory powers, and remain stationary upon their victims. In the meantime changes equally wonderful have been going on within the abdomen.

Eggs are continually forming, and within these the young mites are as continually developing, passing through their entire metamorphosis, *which includes the acquisition of the fourth pair of legs*, (an exceptional character among mites) within the abdomen of the mother, from which they make their way as fast as they reach maturity.

The females are quite prolific. I have counted frequently from forty to fifty young and eggs within the abdomen, and believe that they produce even more. The mothers survive the birth of a large number, if not a majority of the young. The male I have never found, and I am inclined to believe with Mr. Newport, that the species is parthenogenous.[10] The minute size of those young mites admits of their free access to the larvae of the moth, through the very small opening where this made its entry, and a single mite with its progeny would be sufficient to destroy it.

That this is very often the manner of attack is proved by the fact that grains in which the larvae is badly infested frequently have no other break in the hull by which even a young mite could gain admission. Like the larvae on which they subsist, their development is retarded or increased by the temperature, they being quite active at a temperature of 60° Fah.; but in colder weather able to remain within the abdomen of the parent for months in a dormant state, awaiting a rising temperature.

While, as stated, this was probably the first published record of the occurrence of this *Pediculoides* in America, I have since had reason to believe that it was present many years prior to this date, and, indeed, in the light of information that has been obtained during the present year, 1909, it seems altogether probable that it not only occurred but became noxious to man, in Massachusetts, as early as 1830.

The particular reference, however, to which attention is called may be found in the "Prairie Farmer" for the year 1845, page 216. Much is here made of larvae attacking the stems of wheat above the upper joint and in connection therewith follows this significant sentence: "In one instance nine eggs were found in a

10. I have since observed the male though only occasionally, as it is probable that each ♀ produces but one ♂ among her numerous progeny.

single straw, one of which had just hatched." Also, in another journal, we are told that specimens of infested straw were forwarded to the "Country Gentleman" from Scipioville, New York in 1879, which the sender stated contained eggs besides larvae and pupae. In both cases, the larvae were almost beyond a doubt those of *Meromyza americana*. According to my own observation, these mites attack the larvae of *Meromyza americana* in stems of wheat, and, when observed, one cannot fail to be struck with the clearness with which the statements just given describe larvae of this species in the stem of grain or grass being attacked by these mites, the gravid ♀ of which has every appearance to the unaided eye of being a minute egg. It therefore seems not improbable that this *Pediculoides* was abroad over the country at the earlier date, 1845, which would antedate by several years the description of the species by Newport in England; who called attention to the occurrence of this mite as a parasite in the nests of *Anthophora retusa*, in a paper read March 5, 1850, before the Linnean Society of London, and with the description published in the transactions of this Society, Volume XXI, 2, p. 95, 1853.

In the account given by Dr. T. W. Harris in the second edition of his "Insects Injurious to Vegetation" in connection with his discussion of the early occurrences of the barley Isosoma, *Isosoma hordei*, there are two very significant statements that have until lately puzzled me very greatly. On page 438, edition of 1852, he states that "in the summer of 1831, myriads of these flies (meaning the adult *Isosoma*) were found alive in straw beds in Gloucester; the straw having been taken from the fields the year before. An opinion at that time prevailed, that the troublesome humors, wherewith many persons were then afflicted, were occasioned by the bites of these flies; and it is stated that the straw beds of Lexington, being found to be infested with the same insects, were generally burnt." The second reference occurs on page 440 of the same volume, in which it is stated that "about eight years ago (which would be about 1844) some of these insects (again referring to *I. hordei*) that had come from a straw bed in Cambridge were shown to me. They had proven very troublesome to children sleeping on the bed; their bites or stings being followed by considerable inflammation and irritation, which lasted several days. So numerous were the insects that it was found necessary to empty the bed-tick and burn the straw."

Now, since first beginning the study of *Isosoma*, it has always been a puzzle to me, why it was that the adults of *Isosoma hordei*, as they were described by Dr. Harris, should have been able to bite through bed-ticking and cause the eruption described, and yet not be able to gnaw through this cloth and make their escape, as every one who has reared these insects in confinement has witnessed their frantic efforts to escape as soon as they gnaw their way out of the straw. It seems to me that, in this mite, now, we have as good an explanation as we can expect to secure, after a lapse of three-quarters of a century, with no possibility of obtaining actual proof in the case.

In 1884, I found this same mite attacking and destroying the larvae of *Isosoma grande* at Oxford, Indiana, and in speaking of the occurrence of this larva and its parasites, I made this statement: "Curiously enough, during the time it occupies the stubble in the larval and pupal stages, it sometimes falls a victim to the mite *Pediculoides* (*Heteropus*) *ventricosus*, which enters the stubble from above after the grain is cut, but whose sense of discrimination is rather poorly developed, and it is finally victorious over the *Isosoma* larvae, its parasites, and the predaceous larvae of *Leptotrachelus dorsalis*." The same year, and in the same locality, I again encountered this mite attacking the larvae of *Meromyza americana* in wheat straw, and again noted the remarkable resemblance of the gravid females to minute eggs. Since that time, this *Pediculoides* has been reported by Mr. E. H. Ehrhorn attacking the larvae of the peach twig borer, *Anarsia lineatella* Zeller, in California.[11] The same year Mr. Marlatt reports it as attacking the eggs of the periodical cicada *Cicada septemdecim*.[12] Still later, in 1904, Messrs. W. D. Hunter and W. E. Hinds in Bulletin No. 45, Division of Entomology, page 107, called attention to its attack on the larvae of the cotton boll weevil. In 1908, Mr. W. Dwight Pierce, in Bulletin No. 73, Bureau of Entomology, page 30, states that this mite is a common weevil parasite in Mexico. In the same publication, page 42, he accredits it to being parasitic not only on the cotton boll weevil, *Anthonomus grandis*, but also on an allied species, *A. eugenii*. Dr. A. D. Hopkins informs me that in his studies of forest insects, he has encountered it attacking the larvae of wood boring beetles and at

11. Bulletin No. 10, U. S. Dept. of Agriculture, Div. of Entomology, p. 17, 1898.

12. Bulletin No. 14, Div. of Entomology, n. s. p. 104.

one time, in West Virginia, it caused considerable mortality in his breeding cages, where he was attempting to rear wood-boring Cerambycidae and Scolytidae, precisely as experienced, in France, by M. Jules Lichtenstien.

Mr. W. J. Phillips observed this mite attacking the larvæ of *Mordellistina ustulata*, in Indiana, October 3, 1905, while investigating the occurrence of these larvae in the stems of timothy and other grasses.

In the publication of Messrs. Hunter and Hinds, previously referred to, some information is given relative to the attempt to use this mite artificially in overcoming the boll weevil. It has been experimented with quite extensively by Prof. A. L. Herrera and his assistants of the Mexican Commission of Parasitology, and upon his return from a trip to Mexico in the fall of 1902, Mr. Hunter brought with him, through the kindness of Prof. Herrera, a supply of the parasites, from which others were reared for experimental work in Texas. This experiment, however, owing to conditions beyond the control of man, perhaps happily so, appears not to have resulted satisfactorily. One of the principal obstacles in this case seems to have been that, where the mites succeeded in establishing themselves, they were subsequently destroyed by the attacks of small ants.

These references show quite clearly the wide distribution of this mite throughout the United States and its great variety of host insects. We have, in later years, come to consider it a very useful parasite and one that is likely to attack almost any soft-bodied larvae, beyond the reach of insecticides, but to which it, by reason of its minute size, could gain access and be secure from other predaceous insects and adverse meteorological conditions.

The Mite Becomes Noxious to Man.

While, as stated in the earlier portion of this paper, either this or some other closely allied species has long been known to occasionally attack man and animals in Europe, when these are engaged in handling or come into contact with grain or straw infested by their host insects, the first instance of this character to be noted in America has been communicated to me by the present presiding officer of this Society, Dr. Henry Skinner, of Philadelphia, Pa. It was about the year, 1894 while Dr. Skinner was practicing medicine in Philadelphia, that the owner of a boarding house in one of the New Jersey suburbs of the city came

to him in great distress, stating that the tenant and keeper of the boarding house, which accommodated about seventy-five persons, would not pay the rent thereon, and further stated that the tenant had been threatened with legal proceedings by the boarders who had even suggested bodily injury. The cause of all of this trouble was an epidemic of a rash like disease, the causes of which were suspected to lie in the mattresses of the beds occupied by the patrons of the house, because of the occupants having been attacked by a very mysterious and aggravating skin eruption. The owner submitted straw dust and mattress debris taken from the suspected beds and on examination of this Dr. Skinner found specimens of this mite. The house was promptly deserted by the boarders, none of whom as it seems escaped infection and none of whom were willing to return. The matter does not appear to have been further investigated.

In the Philadelphia Medical Journal for July 6, 1901, Jay F. Schamberg, M. D., of Philadelphia, published a short paper, calling attention to and describing "An Epidemic of a Peculiar and Unfamiliar Disease of the Skin." In this paper, Dr. Schamberg, who, besides being a practicing physician, is professor of Dermatology, and Infectious Eruptive Diseases, in the Philadelphia Polyclinic, described a number of cases that had been treated by him a few weeks prior to the publication of this paper. The eruption and its effect on the patient were briefly described and illustrated, but the causes instrumental in bringing about these attacks were still unknown to him; and as several members of the same household were commonly affected the disease was considered likely to prove contagious. The dermatitis, however, was not lost sight of, and in a paper contributed to the Public Health Reports, Volume XXIV, No. 28, July 9, 1909, Dr. Joseph Goldberger, Past Assistant Surgeon of the United States Public Health and Marine Hospital Service, in cooperation with Dr. Schamberg, published the first exact information we have relative to the cause of these epidemics and this paper, so far as known to me, is the first publication in this country in which the attack of this mite has been followed up and its dermatological effect on humans carefully studied and described. This paper of Drs. Goldberger and Schamberg may be briefly summarized as follows:

In the spring and summer of 1909, this peculiar eruptive disease became quite prevalent in Philadelphia and neighboring

towns. An outbreak among 20 sailors upon a private yacht docked in the Delaware River attracted the attention of both the city and the Federal Health Authorities. The Surgeon-General of the U. S. Public Health and Marine Hospital Service delegated Dr. Joseph Goldberger, Passed Assistant Surgeon, to proceed to Philadelphia in order to make an investigation of the disease.

After examining the 20 sailors who had been sent to a hospital, Drs. Goldberger and Schamberg visited the yacht whence they came and made a searching examination of the conditions on board. Their attention was directed to the fact that a number of new straw mattresses had been received and that the disease was confined to those who had slept upon these mattresses or had placed their clothes upon them. Eleven officers and members of the crew who did not sleep upon the new mattresses remained entirely free of the disease.

At about the same period information was received concerning an eruptive disease prevailing among the sailors of four other boats, plying along the Delaware River. Investigation disclosed the fact that these boats had also received new straw mattresses, and, furthermore, that only those were attacked who slept upon the mattresses or otherwise came in contact with them.

In addition to these cases among sailors, Doctors Goldberger and Schamberg examined or received authentic information concerning 70 other cases of this disease occurring in twenty different households in Philadelphia and its vicinity. Plate IV.

In practically every instance they were enabled to determine that the patient had either recently slept upon a new straw mattress or had freely handled the same. Where only one person in a household was affected, it was found that he was the only one to occupy a bed supplied with a new straw mattress. They were able to trace all of the incriminated mattresses to four leading mattress manufacturers.

Careful investigation warranted them in excluding from consideration the ticking of the mattresses and the jute or cotton topping contained therein. The cause of the disease was, therefore, circumscribed to the straw. Repeated inquiries elicited the information that all of the manufacturers had received at the time the disease-producing mattresses were made up, wheat-straw from a dealer in Salem County, in southern New Jersey.

One manufacturer had used straw from this source exclusively in the affected mattresses.

Finding of a Parasite. Drs. Goldberger and Schamberg sifted the straw from a mattress through the meshes of a fine flour sieve upon a large plate glass covered with white paper. Close scrutiny of the siftings under strong electric illumination soon detected some slight motion. The moving particles were touched with a needle moistened in glycerine and transferred to a glass slide. Search with the microscope disclosed the presence of a mite of very minute dimensions. The mite was identified for them by Mr. Nathan Banks, expert in Acarina of the U. S. Bureau of Entomology, as very close to, if not identical with, the *Pediculoides ventricosus.*

In order to demonstrate experimentally the ethiological relationship of the suspected straw mattresses, Dr. Goldberger exposed his bared left arm and shoulder for one hour between two mattresses. At the end of about 16 hours, a number of characteristic lesions appeared upon the arm, shoulder and chest. Later three volunteers slept upon the mattresses and each one developed the eruption at the end of about the same period.

Dr. Goldberger later took some of the sifted straw, divided it into two portions and placed it in two clean Petri glass dishes. One of these was applied for one hour to the left axilla of a volunteer. At the end of from 16 to 17 hours, the characteristic eruption was present in the area of the left axilla to which the Petri dish of straw siftings had been applied.

The second portion of the straw siftings in a Petri dish was exposed to the vapor of chloroform under a bell jar with a view to killing any insect or acarine that might be present. These siftings were then applied to the right axilla of the same volunteer to whose left axilla the untreated siftings had been applied. The chloroform evidently destroyed in the siftings the agent that was producing the eruption for no lesions appeared after the application of the chloroformized siftings.

Dr. Goldberger further fished out of some straw siftings five minute mites, and, placing them in a clean watch crystal, applied the crystal to the axilla of another volunteer. At the end of about 16 hours following this application, five of the characteristic lesions appeared on the area to which the mites had been applied. Plate V, fig. 1.

Influences Controlling the Excessive Abundance of Pediculoides.

It will be noticed that Drs. Goldberger and Schamberg made no attempt to discover the underlying causes for the enormous numbers of these mites inhabiting the mattresses involved in their investigations, that problem belonging more properly within the realm of the entomologist. On my taking up this subject of the excessive abundance of the mites, Drs. Goldberger and Schamberg very kindly placed at my disposal everything in their possession relating to this epidemic, including the mattress which Dr. Goldberger had himself used in experiments carried out by him at the hygienic laboratory in Washington with this mite. Dr. Schamberg was equally kind in placing all of the material, notes and photographs in his possession, at my service.

Almost at the commercement of the investigation, Dr. Wm. Royal Stokes of the Maryland State Board of Health informed me that a similar but less extensive epidemic had shortly before been noted in Baltimore, This he kindly described as follows:

"The matter was brought to my attention by several persons who came to the Head of the Department and complained of the skin eruption described. They stated that a number of people in a suburban hotel were similarly affected, but I do not remember the number at this late date. These persons volunteered the information that they had all been sleeping on some new straw mattresses, and that all of the persons similarly affected had used these mattresses.

"I saw Dr. Gilchrist, the Clinical Professor of Dermatology at Johns Hopkins University, yesterday, and he gave me the following description of the one case which he saw at the Health Department. I saw two other cases which corresponded with these in a general way.

" 'The eruption consisted of about 1000 wheals, or erythemato-withicarial spots, or pauplo-withicarial lesions. As in the description in the reprint of Drs. Goldberger and Schamberg of the United States Public Health and Marine Hospital Service, they varied in size from a lentil seed to a finger nail, and are round, oval, or irregular in shape. No vesicles or pustules were seen. The eruption was on the neck, chest, abdomen, and back, and also on arms and legs. Itching was present, and all lesions showed evidences of scratching.' "

Besides this, there were several cases reported to me from northern Maryland, where farmers in running their wheat through a fanning mill had been simultaneously troubled by a very similar or identical eruptive disease of the skin. In another instance, a thresherman engaged in feeding the unthreshed grain into the cylinder of the threshing machine was also affected by a disease of the skin, with which the attending physician was unfamiliar and who could not classify it with any of the urticaroid dermatitis known to him. With my experience of previous years, it seemed impossible that this *Pediculoides* should become sufficiently abundant to cause this dermatitis without there being an excessive abundance of some host insect or insects affecting either the straw or the grain itself. Naturally, the studies made by me in 1882, led me to suspect that this grain moth *Sitotroga cerealella* might be responsible for the abundance of the mites. Then, too, the fact that it attacked the larvae of *Isosoma grande* in wheat straw, led me to suspect that, as this particular species is not known to occur in the vicinity of Philadelphia, while its near relative, the joint worm, *Isosoma tritici*, does occur more or less abundantly over the eastern part of the country, this latter species, too, might perhaps be involved.

With a view of finding out something of the abundance of the grain moth in New Jersey, from which State was obtained most but not all of the straw entering into the mattresses mentioned by Drs. Goldberger and Schamberg, I applied to Dr. John B. Smith, State Entomologist, for information. In reply Dr. Smith was kind enough to send me an advance copy of the report of his department of the New Jersey Agricultural Experiment Station for the year 1908, and from this publication it was learned that during the summer of that year, owing to favorable weather conditions, this moth developed rapidly in the field and there was great damage to wheat among those farmers who delayed threshing until September or later. Furthermore, a very large percentage of the wheat crop gathered that year became useless for milling purposes and so general was the infestation that grain from some localities was entirely barred at mills except when ground for the owner. Some further investigations carried on in eastern Pennsylvania revealed a very similar condition of affairs. It was the straw of 1908, coming mostly from New Jersey, but a small part of it from Indiana, that en-

tered into the mattresses, from the use of which came the epidemic in and about Philadelphia.

In order to settle these points, Mr. V. L. Wildermuth, an assistant in the Bureau of Entomology, in cereal and forage insect investigations, was instructed to examine the straw in the mattress placed at my disposal by Dr. Goldberger. After a day and a half of careful search, only five straws affected by the joint worm were found. This seemed to entirely eliminate this species from consideration in connection with this particular epidemic. There were, however, many wheat heads remaining attached to the straw and these heads contained a great many kernels, the contents of which had been eaten out by the larvae of the grain moth. Morever, these eaten kernels contained great numbers of the dead bodies of Pediculoides. That *Sitotroga cerealella* was the cause of this damage to the wheat was still further proven by the emergence of an adult moth from these eaten kernels on November 15. The larvae of this moth infested the kernels of wheat before the latter were threshed. Many of these infested kernels remaining in the straw were included in the material going into the manufacture of these mattresses. The greater portion of the living larvae of the moth would develop to adults during May or early June, thus cutting off the food supply of these mites. The mites would therefore very naturally swarm among the straw and making their way through the cloth covering of these mattresses attack anything that gave promise of furnishing food, and preserving them from starvation. It seems that starvation is the final outcome, however, for, as already stated, no trouble is experienced in using the mattresses after a certain period, which period probably indicates the termination of the life of the mites infesting the straw. It therefore did not seem necessary to seek farther for the primary cause of this eastern epidemic of dermatitis, the center of which seems to have been in and about Philadelphia.

A Western Epidemic of the Dermatitis.

While the problem of the epidemic in the east was apparently solved, some of the wheat straw involved therein had come from Indiana, and during the last few years an outbreak of the joint worm, *Isosoma tritici*, had been gathering force, throughout Ohio, Indiana and southern Illinois, until during the summer of 1908, very serious damages occurred. Investigation of the insect dur-

ing previous years had shown that the outbreak really began in the more elevated portions of Virginia, in the upper Shenandoah Valley, West Virginia and eastern Ohio, as early as 1904; afterwards advancing broadly to the westward.

During the summer of 1908, there came to the Bureau, from this section of the country, a great number of complaints of serious skin trouble among people engaged in threshing grain that had been stored for some time in barns; in some localities it having become difficult to secure help to thresh under such conditions. Also the same disorder was encountered by those who used this straw for the purpose of filling bed-ticks, or as a substitute for felting under carpets, and in one case, berry pickers had been attacked when such straw had been used as a mulch for berry plants. This straw came from one of the fields most seriously injured by joint worm attacks in 1908. In one instance, a carload of wheat straw was shipped to Pittsburg, Pa., and six men engaged in unloading it, were all attacked by some skin eruption, and the horses used in hauling this straw after it was unloaded, also suffered from what was seemingly the same disorder. Perhaps the following from a correspondent of the Bureau of Entomology, residing in southern Ohio, will give a fair idea of the situation on many farms in that section of the country.

"About four years ago a parasite was found when threshing wheat out of barns. They seem to affect the victims almost as soon as they get into the mow. The men began to scratch themselves generally on the neck and on the arms (inside) opposite the elbow, and on the body back and front. They raised welts as you describe and progress about as you describe. They have spread to such an extent that farm hands dread and fear them and will not change work with neighbors unless they thresh in the field. (They are found out of barns.) Here of late they are found in wheat straw in the barns, especially if baled. Last week a farmer brought me baled wheat straw that seemed to be alive with them. They attacked every one that went in the barn and one of my horses that was perspiring from effects of a drive was simply covered with little knots or swollen places and bit and rubbed himself continually. I had to have the straw hauled out and burned and barn disinfected. The farmer stated that they were so thick in the shed that contained the straw, that he had to keep all stock out of the shed."

Many other similar letters from towns in Ohio were received by Dr. Schamberg, particularly from Zanesville, Columbus, Vincent, Springfield, etc., where the affection is popularly believed to be due to "chiggers." A physician from the last named town stated that in the fall of 1908, during harvest and threshing time he saw in Washington County some 87 cases of the disease in question. It affected the harvesters and threshers. This spring he observed 38 cases from contact with straw ticks refilled with straw of last fall's crop. The disease is said to have been more prevalent last year (1908) than ever before. Information has come from Columbus, Ohio, that potters who used straw for packing crockery ware have been so badly attacked at times that the entire force of packers has been off duty. Many times a whole car-load of straw has been so affected that the use of it has been abandoned. In Springfield, Ohio, it is said that the disease was so bad a year or two ago in the lowlands west of this city as seriously to hamper the progress of the construction of a large sewer. This, however, might have been due to attack by other mites, notably to Trombidium larvae. In Zanesville, Ohio, the potters have been obliged to abandon the use of straw and employ "prairie hay" for packing purposes.

Dr. Schamberg was also informed by a physician of Pittsburg that a young woman patient has suffered from an affection closely resembling, if not identical, with the one under consideration, each time that she has assisted in emptying cases of dishes packed in straw. Both the physician and the patient had come to believe that something in the straw was the cause of the eruption.

Indeed, so nearly did the territory from which these complaints came to us, coincide with that affected by the joint worm, that it created the suspicion, not only among those engaged in the investigations, but even among farmers themselves, that there must be some connection between the two phenomena. Very many of these cases were brought to the notice of practicing physicians, but they were themselves at a loss to account for the prevalence of this dermatitis, many of them supposing it to be some species of rash that was more or less contagious, the exact nature of which they did not know.

Among these physicians was Dr. Lyman T. Rawles, of Huntertown, Indiana, who in May, 1909, took up a careful study of a number of cases of this dermatitis that had come under his personal observation as well as those of some of his associates. Dr.

Rawles' investigations were very carefully made and the results are exceedingly valuable for the reason that, in case of this western epidemic, he was able to trace the cause of the dermatitis to *Pediculoides ventricosus* and follow this back to the host insect *Isosoma tritici*. This paper of Dr. Rawles[13], of which a summary is given, not only clears up the obscurity with reference to the cause of this epidemic in the Middle West, a section throughout which the grain moth (*Sitotroga cerealella*) never occurs in excessive abundance excepting in grain that is kept in store, and then only in the more southern portions of Indiana and Illinois; but, furthermore, these studies seem to solve the problem of the cause of the skin eruption noted by Dr. Harris to have occurred as far back as 1830.

In May, 1909, Dr. Rawles found in his practice that a very strikingly strange skin disease presented itself in his and surrounding country in epidemic form. Through the press notes it seemed to be quite general over the northern part of the United States, limiting itself to the wheat growing sections.

The people generally affected were farmers and those living in small villages or towns where straw is used in beds, under carpets and around stables to bed stock. Horses and cattle have been seen with a skin disease almost identical to that seen in man. The following incident led him to an investigation as to the probable etiology:

A family had cleaned house, refilling the straw ticks of their beds and placed fresh straw under the carpets, and in about one week the family had developed this peculiar skin disease. In the beds were found a small, black fly, *Isosoma tritici* Fitch, about the size of an ordinary gnat, which at first it appeared to be, but closer observation revealed that it was not of the gnat family. Upon examination of the straw it was found that a large number of the straws were perforated; these perforations were through the wall in the region of the joint, generally about two inches from the joint. The perforations were about the size of a small pinhole and ranging in number from ten to thirty in a straw. Upon examining a section of this straw the *small black fly* was found *under many* of the openings through the walls.

Several flies were examined to ascertain if they possessed a piercing proboscus, and while observing one which has just been taken from under the sheath of the straw, through which there

13. Journal of the Indiana State Medical Association, August, 1909.

was no perforation over the fly, a small mite was observed crawling over the dead body of the fly.

Placing the bodies of several of these flies under the microscope and using a ¼-inch objective and a No. 5 eye-piece, it was found that on nearly all flies over which the wall was intact, a small mite could be detected, these mites varying in number from two to four mites to each fly. Upon furthering the observations it was found that the dermatitis lasted after the flies had been observed and exterminated.

The following experiments were tried to prove whether it might be the fly or the mite that was the etiologic factor in producing the dermatitis.

Six live flies were taken, upon which no mites could be found; these were placed under a watch glass and bound upon the right arm, leaving them in contact with the skin for three hours. Upon the left arm four dead flies, on which living mites had been observed, were placed under a watch glass and left in contact with the skin for three hours, after which the glasses were removed and results awaited. The right arm showed nothing. Upon the left arm there appeared within twelve hours four small wheals, the character and evolution of which are later described.

To further the experiments some fresh lesions of patients were scraped and the scrapings examined microscopically and two of the mites were found in the scrapings.

Itching is the most prevalent and first symptom to attract the attention of the patient. It is most persistent and intense during the after part of the night. At about the time the itching was most intense there appeared an urticarial eruption, accompanied, in severe cases, with general systemic symptoms, such as rise of temperature from 99 to 102; in one case the temperature rose to 103.8; the pulse rate is accelerated to 100, or as high as 110—in one case to 130. Other symptoms were intense headache, anorexia, nausea, in some cases vomiting, and a mild form of diarrhoea. In severe cases some complained of general joint pains and backache; in these cases the urine was examined and albumin in small amount was found, but no casts or blood. When the acute symptoms disappeared so did the albumin.

Many patients who suffered from mild cases complained of nothing aside from the intense itching. If all straw was removed from the beds and house the symptoms would subside in one or two days and completely disappear in a few days more.

The lesion which is typical of the disease is the urticaria vesiculosa. The urticarial lesion varies in size from that of a split pea to that of a penny; it is surrounded by a pinkish halo, varying in intensity of color from a pale pink to a most bright pink. The "hive" like lesion is at first blanched, but later becomes a rose red color. It is elevated about 1 or 2 mm. above the skin surface, and is surmounted by a small vesicle containing a whitish fluid marking the place of inoculation. The vesicle is about 1 or 2 mm. in diameter and elevated about 3 mm. above the surface of the urticarial lesion. As the lesion grows old it goes through the process of evolution: (1) it is blanched and has a central vesicle; (2) it is rose red and the vesicle may become a pustule; (3) it generally recedes to the skin level with scab formation, due to the scratching; (4) it leaves a browinsh or greenish-yellow or purple spot on the skin surface. In debilitated patients the markings look not unlike faded indelible pencil marks. (This was noted in a patient suffering from pulmonary tuberculosis.) These discolorations may last for several weeks.

The anatomical location of the lesions is generally the back, sides and abdomen, and less frequently the arms and legs. The neck has very few lesions; the face, hands and feet have very few or none.

The number of lesions depends upon the number of mites, ranging in number from very few to thousands; in some cases the back and abdomen have been almost a solid mass of lesions—new lesions on the tops of old lesions, so having lesions in all stages of development.

Obscurity Surrounding the Occurrence of the Dermatitis.

The exact nature of this eruptive disease was not at all understood by the medical profession throughout the country. In South-western Virginia, threshermen suffered from the same disorder, but attributed it to "chiggers," and local physicians, though skeptical, were themselves unable to correctly diagnosis or to account for the trouble. As the disease is not serious and passes away in the course of time without leaving the patient in any way permanently injured, it seems to have been passed over by medical men without investigation excepting by the physicians whose publications have just been cited. Among the people themselves the eruption was probably more frequently attributed

to attacks of "chiggers" than to any other cause and it is quite likely that this common erroneous interpretation of the origin of the eruption has prevailed generally throughout the country, including the upper Shanandoah Valley in Virginia, where the joint worm was abundant as far back as 1904. It has been confused with small-pox and more frequently with chicken-pox. It, was, consequently, exceedingly unfortunate that, with the beginning of this disorder, an institution in one of the States involved, should publish an unsigned newspaper bulletin, crediting these epidemics of this eruption to the attack of "chiggers," and, furthermore, at the very time when Drs. Goldberger, Schamberg and Rawles, as well as the Bureau of Entomology, were exerting every effort to find out the true cause of the difficulty, that a second press bulletin, accentuating the first, should have been issued, and, sent to every newspaper in the State, and from those copied into other newspapers throughout the country. Thus it is that an entirely erroneous impression has been magnified and diffused, still continuing to prevail throughout the country.

In order to determine the likelihood of those handling straws in the wheat field, being attacked by the small red mites, often innocently mistaken for "chiggers," that abound among the harvested grain at this time, Mr. Wildermuth made a number of experiments to determine whether or not these mites, probably Tydius sp., were liable to attack men. In no case was he able to provoke an attack from them, even when they were confined upon the skin of his bare arm. On the other hand, examination of straws from various points in Ohio and Indiana have revealed the presence of *Pediculoides* in the cells occupied by the joint worm. This seems to entirely eliminate "chiggers" from these investigations, because these were probably not present, and there does not longer appear to be any doubt but what *Pediculoides ventricosus* is to be charged with causing these epidemics of this dermatitis, and the cause of its own excessive abundance lies in the outbreaks of the Angoumois grain moth among the grain itself in the East and the joint worm in the wheat straw in the Middle West.

Light Thrown Upon Other Problems.

These investigations have illustrated very nicely the extent to which the solution of one entomological problem will at the same time also solve other problems more or less closely allied to

the original one. The light thrown upon the cases of eruption noted by Dr. Harris with reference to *Isosoma hordei* has already been explained. The present outbreak of the joint worm in the Ohio Valley probably originated in the upper Shenandoah Valley of Virginia, extending northward and westward throughout West Virginia and eastern Ohio. When investigation of the insect was taken up in 1904, a parasite, *Ditropinotus aurcoviridis*, was also noted in excessive abundance, but for some reason it did not overcome the joint worm. This phenomenon has been noted continually. Since that time it has been a perpetual enigma to me why it was that with such an abundance of its natural enemies the joint worm should continue to spread and increase in destructiveness. Now, however, that we know that this predaceous mite is able to develop through a series of years in such immense numbers in connection with the joint worm, the matter comes nearer a solution. *Ditropinotus*, as well as some other parasitic enemies of the joint worm, emerge in early July from eggs that were previously placed in the cells occupied by the joint worm. As soon as these adult parasites emerge they at once oviposit in cells containing joint worm larvae of the same generation from which they themselves developed. The puncturing of these cells by the ovipositor of these parasites, particularly *Ditropinotus*, opens a way for the entrance of this microscopic mite, and, once inside of the cell, it will destroy everything therein, whether it be joint worm or parasite. Thus the predaceous mite has prevented the other parasites from exerting their full influence, because it has continually checked the increase of other parasites, thereby preventing them from increasing and exerting the restraining influence upon the joint worm that, but for this mite, they probably would have done.

In the light of the foregoing, it would appear that the only way to evade this disorder among humans, caused by this mite, lies the prevention of the occurrence of these two destructive grain insects which are responsible for the abundance of the mite itself. There is, therefore, a double incentive for the farmer to use every effort to prevent the occurrence of these pests in his fields. In many fields in Ohio we have found that more than one-half of the straws had been attacked by joint worm, and the damage resulting from their attacks amounted to a considerable percentage of the farmers wheat crop. See Plate V, fig. 2. If, in addition to this, his own family and employees are to suffer

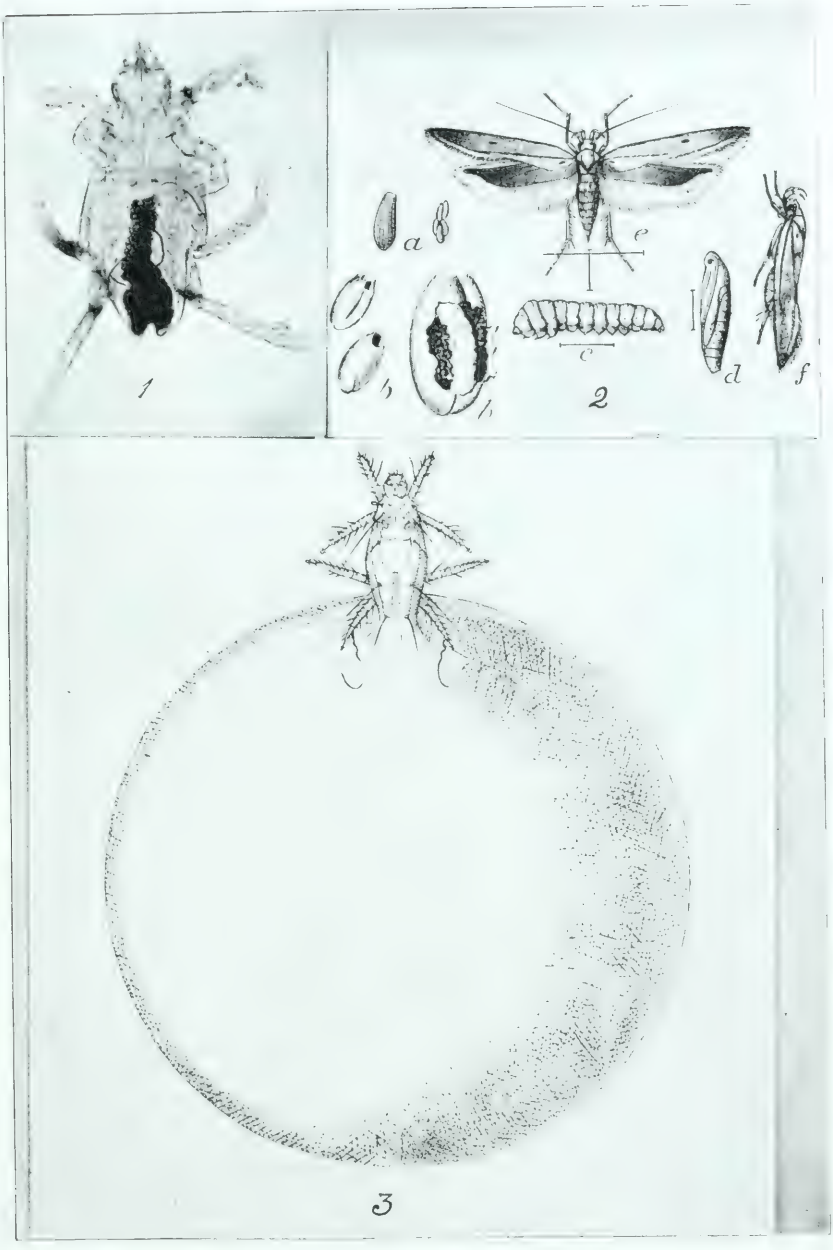
annoyance from this dermatitis, and we know that the mite is present generally, also those who attempt to use mattresses into the construction of which the straws from these fields have entered and indeed in even handling the same, the results of his agricultural methods will be sent wherever, in the entire country, these mattresses, or the straw itself, go into practical use within at least a year from the time the wheat straw was harvested in the fields, and thus people hundreds of miles away, with no possible means of knowing of the presence of these mites in mattresses, are caused not only great aggravation but intense suffering through their use.

Preventive and Protective Measures.

From the foregoing, it will be observed that that public protection from this skin disorder is only to be secured through revised agricultural methods of the farmer, who, while offering this protection, will also materially increase the profits of his business. Throughout the territory involved in the eastern epidemic of this dermatitis, which, as has been shown, was due to the excessive abundance of the Angoumois grain moth, the evidence recently attained by the writer has been overwhelmingly to the effect that where wheat was threshed as promptly as possible after harvest and directly from the shocks in the field, almost no occurrence of this grain moth was observed by millers and others handling the threshed grain, and without which there would have been no mites. On the other hand, when drawn from the field and placed unthreshed in the barn, the damage from this pest has varied up to nearly fifty per cent., and has so affected the crop as to cause its rejection by millers, except where ground on the farmer's order. Here, then, lies the protection of people who use mattresses made of this wheat straw, grown in this section of the country, or otherwise come in contact with the same. Reiterating in a condensed statement: Wheat should be threshed immediately after harvest and directly from the field.

In Ohio, Indiana and Illinois, where the mite causing this dermatitis has increased enormously on account of the prevalence of the joint worm, see Plate V, fig. 3, wheat also placed in barn before threshing has been found to be much more dangerous to handle with reference to epidemics of this disorder. At the same time, the difference between wheat threshed in the field and in the barn is not so striking as where the primary trouble was in the abundance of the grain moth.

A careful study of a large number of wheat fields in central Ohio, has shown that the infestation from joint worm, the present



Webster on Pediculoides

Webster on Pediculoides

Webster on Pediculoides

season, has varied from one to ninety-five per cent. Here, too, we have found the mite generally in the cells in the straw occupied by the joint worm larvae. It has been found that in central Ohio, September sown wheat was much more seriously affected by the joint worm than that sown in October, and also that the infestation is worse in both cases on poor soil than on that of an average degree of fertility, and still less on good soil. The infestation was invariably worse in fields lying adjacent to or where wheat had been grown the previous year. Another interesting fact was revealed, and that is that fall plowed fields showed the least infestation of all. Therefore, it appears that moderately late sown wheat on good soil and on land not devoted to wheat the previous year, nor lying adjacent to such fields, has escaped with the least injury, and that less difficulty with the dermatitis is experienced where such wheat has been threshed from the field and as soon as possible after the grain was harvested. As the joint worm winters over in the stubble, where this can be burned during the fall, winter or spring, the destruction of the pest in the field will be complete. Where this cannot be done, much good may be accomplished by raking over in the spring the last year's stubble fields and burning the stubble thus collected. So important are these measures that practicing physicians might almost include them with their prescriptions for this painful skin disorder.

Explanation of Plates.

Plate III.

Fig. 1. *Pediculoides ventricosus* Newport, ungravid ♀. Stage in which the mite is both migratory and predatory and in which it attacks humans. From photograph by Dr. Jay F. Schamberg. Greatly magnified.

Fig. 2. The Angoumois grain moth, *Sitotroga cerealella* Oliv., *a*, eggs enlarged; *b. b.*, bernels of wheat infested by larvae; *c*, larva, enlarged; *d*, pupa; *e*, moth with wings spread; *f*, same with wings closed as at rest. Figs. *b.b.*, original remainder, after Chittenden, Farmers' Bulletin, U. S. Dept. Agriculture, No. 45, p. 6.

Fig. 3. *Pediculoides ventricosus*, gravid ♀. Greatly enlarged. Redrawn from Brucker.

Plate IV.

Illustrating various forms of the dermatitis lesions caused by attacks of *Pediculoides ventricosus*. From Photographs by Doctor Schamberg.

Plate V.

Fig. 1. Lesions caused by bites of *Pediculoides ventricosus*, in experiment of Dr. Joseph Goldberger. From drawing by F. H. Wilder. Courtesy of Public Health and Marine Hospital Service.

Fig. 2. Showing reduction in yield of wheat attacked by jointworm, *Isosoma tritici* Fitch. The tube at left contains yield from 100 heads from uninfested straws; tube at right contains yield from 100 heads from infested straws. Photographed by W. J. Phillips, Bureau of Entomology.

Fig. 3. Showing attack of joint-worm, *Isosoma tritici*, in field. Note the enlarged and distorted stems. From photograph by Geo. I. Reeves, Bureau of Entomology.

MYRMELEONIDÆ FROM AUSTRALIA.

By Nathan Banks.

The ant-lion flies of Australia have been mostly described by Walker and Gerstaecker. In collections sent to me by Mr. Dodd, from Kuranda and Port Darwin, and by Mr. Perkins, from several parts of Queensland, are a number of the described species and several that are new. These are described in this paper.

The Australian Myrmeleondiæ are more like the European forms than like those of the United States. Two genera, *Myrmeleon* and *Acanthaclisis*, they have that occur also with us, but these genera are generally distributed throughout the world. The new general are more allied to the European than to our genera. There is practically no similarity to the South African forms.

The eight genera known to me can be tabulated as follows:

1. No spurs, one cross-vein, before radial sector in hind wings; wings broad **Chrysoleon**
   Spurs present 2
2. One cross-vein before radial sector in hind wings 5
   Several cross-veins before radial sector in hind wings; anal ends before fork of radial sector; pronotum broader than long 3
3. In middle of apical half of each wing is a nearly straight line formed by the bent longitudinal veins and very short cross-veins; anal vein of hind wings runs into lower cubitus, legs short and stout . . **Acanthaclisis**
   No such line of bent veins and short cross-veins 4
4. In both wings the upper cubitus and the median unite long before margin of wings; wings very broad ..... **Callistoleon**
   Upper cubitus and median not united, wings more narrow . . **Myrmeleon**
5. Basal joint of tarsi longer than apical joint; anal ends far out on wings, beyond origin of first fork of radial sector ..... **Protoplectron**
   Basal joint of tarsi not longer than apical; anal vein ends nearer base of wing, at or before origin of first fork of the radial sector 6
6. Spurs as long as first four tarsal joints together ..... **Distoleon**
   Spurs barely longer than first joint of tarsus 7
7. Wings broad in stigmal area, in middle of this area is a straight line as in Acanthaclisis formed by bent longitudinal veins and very short cross-veins ..... **Glenurus**
   Wings more narrow; no such line formed by bent veins and short cross-veins **Formicaleo**

Glenurus pulchellus Ramb.

Mid-Queensland (Perkins) also New South Wales (Froggatt).

Glenurus dissolutus Gerst.

Port Darwin, 12 May (Dodd).

Glenurus stigmatus, n. sp.

Face pale, a large interantennal black spot, a transverse pale band above this, and the vertex brown; antennæ black; pronotum with a broad black median stripe, containing a pale median stripe in fore part, sides pale, streaked and dotted with black; rest of thorax black, with a few small pale spots on the lobes; abdomen black; legs black, tibia I and II with basal and preapical bands pale, sometimes also a median spot above; hind tibiæ pale behind, except tip, and in front at

base and tip pale; base of first tarsal joint pale; legs with short black hair and longer, erect bristles; spurs rather longer than first tarsal joint. Wings hyaline, with many small dots, mostly on forkings of veins, and in apical part, larger ones along radius and cubitus, forming rather oblique lines at ends of anal veins, and on gradate series in fore-wings; stigma a large, black spot in both wings, very prominent; wings of usual shape and much like *G. dissolutus*.

Expanse 80 mm., abdomen long 20 mm. From Kuranda, Queensland, Australia, March, (Dodd).

Protoplectron costatus n. sp.

Face pale, black in antennal region, vertex pale, a transverse black line, and behind it a row of spots, a small trapeze in the middle and two spots each side toward eye; antennæ pale brown, short, with large knob; pronotum brown, darkest behind on sides, paler in middle, with some long white hair, and also on the pleura; abdomen brown, with extremely short white hair; legs pale, femora dark above, tibiæ black at base and tip, tarsi black in middle, pale on most of first and fifth joints, with much long white hair, and some black bristles; tarsal joint I much longer than IV, one-half as long as tibiæ, spurs as long as first joint. Wings hyaline, narrow, acute at tip, and fore wings rather falcate; venation mostly dark, but some patches of cross-veins wholly yellow, and long streaks of pale in the longitudinal veins; stigma brown at base. In fore wings the lower cubitus runs parallel to anal vein for a long distance; but one series of costal cells in either wing; eight branches of radial sector before stigma in fore-wing.

Expanse 48 mm., abdomen 18 mm.

From Port Darwin, Australia, 10 April (Dodd).

Protoplectron pallidum n. sp.

Lower part of face yellowish, upper part and the front black; vertex with a broad transverse pale band from eye to eye, divided on the median line; antennæ yellowish brown, the second joint with a darker ring; pronotum pale yellowish; thorax dark brown on sides, pale through the middle, and a pale spot above base of each wing; pleura mostly pale or light brown; abdomen black, legs pale, rather reddish on femora and tarsi, no bands or marks, clothed with long white hair and black bristles. Antennæ rather longer than head plus thorax; pronotum once and a fourth longer than broad, only slightly narrowed in front; abdomen short, not near as long as wings. Legs rather short; tarsi very slender, basal joint more than one half as long as tibia, the spurs of the same length, joints 2, 3, and 4 very short, 5th joint more than one-half as long as the first, on its basal part beneath are several short, curved spines forming a comb. Wings yellowish hyaline, unspotted; stigma scarcely visible; venation yellowish, or brownish yellow, not dotted. Wings moderately slender, acute at tips, a double costal series of cells in fore wing, single series in hind wing; about 7 cross-veins before origin of radial sector in fore wing, only one in hind wing; in fore wing the first branch of

the radial sector arises long before end of the anal vein, which is nearly one-half way out on the hind margin; apical portions of both wings have the longitudinal veins very close together.

Expanse 58 to 68 mm., abdomen 20 mm.

Several specimens from Port Darwin, Australia, 8 April to 4 May, (Dodd).

Callistoleon n. gen.

Wings rather broad; anal veins of fore-wings ending long before origin of the first branch of the radial sector; posterior branch of cubitus running obliquely down toward anal vein, two series of cells between it and anal vein; about seven cross-veins before origin of radial sector in fore-wings, some crossed; a single series of costal cells; the anterior branch of cubitus and the median vein unite before tip, and from the anastomosis the veins radiate somewhat, to the margin, more strongly so in the hind wings. In the hind wings about four cross-veins before radial sector; the posterior branch of cubitus running obliquely down to margin, before origin of radial sector; head rather broad; antennæ moderately long, pronotum broader than long; tarsal joints short, first much shorter than fifth; spurs a little longer than basal joint.

Type—Myrmeleon erythrocephalum Leach.

Callistoleon erythrocephalum Leach.

Mid-Queensland (Perkins).

Distoleon n. gen.

Wings rather narrow; seven cross-veins before radial sector in fore wings, one in hind wings; anal ends before origin of first branch of radial sector; a single costal series. In hind wings anal ends soon after origin of lower cubitus, not parallel thereto. Spurs as long as first four tarsal joints, fifth joint much longer than first; tarsus I about as long as tibia I; pronotum broad.

Type—D. verticalis; also includes Formicaleo bistrigatus.

Distoleon verticalis n. sp.

Head pale, a black band below and one above base of antennæ, another band above this, narrowly interrupted in the middle or broken into four spots, and on the vertex four spots forming a trapeze in the middle and two each side toward the eye; antennæ brown, annulate with pale; pronotum pale, darker on margin, rest of thorax grayish brown, abdomen blackish, a pale spot above in middle of each segment, legs pale, some black dots at bases of bristles, black and white bristles. Wings hyaline, a dark dot on stigma, one on hind margin one-third the way out at end of anal vein, and two at end of cubitus and median veins, and other smaller spots in apical part of wing, and at forkings of longitudinal veins, these veins black and white in long streaks, some cross-veins all black, others all yellow, others black and yellow. Hind wings with two dots at end of cubitus and less distinctly on apical portion. Antennæ long; legs short, spurs

heavy, curved, as long as first four joints, fifth joint twice as long as first. Pronotum broader than long, not narrowed in front. Wings rather long acute; one costal series, cells in region of gradate series are long and narrow.

Expanse 68 mm., abdomen long 25 mm.

Mid-Queensland, Australia, (Perkins).

Distoleon bistrigatus Ramb.

(M. striola Walk.)

Port Darwin 20 April, 28 August; Kuranda, March; Mid-Queensland.

Chrysoleon n. gen.

No spurs; legs slender, first tarsal joint as long as second plus third, hardly as long as the fifth; pronotum slender. Fore wings broad, hind wings narrower and longer than fore wings; costals of fore wings frequently forked; three cross-veins before radial sector; anal ends a little beyond origin of first branch of medial sector; a double series of anal cells; the lower cubitus running obliquely down to the hind margin. In hind wings one cross-vein before radial sector; anal ending beyond origin of first branch of radial sector; lower cubitus running down to margin, upper cubitus uniting with median before tip of wing.

Chrysoleon punctatum n. sp.

Head yellow, a faint dark mark each side on vertex; antennæ yellowish, darker at tip; pronotum pale, with some scattered brown dots; rest of thorax mostly pale; abdomen pale, a black stripe each side; legs pale, minute brown dots at base of bristles, not distinct on hind tibiæ. Wings hyaline, outer apical part of fore wing with small brown clouds at forks of veins, and one under the stigma, also in hind wing, but fewer in the posterior apical part. Venation pale, frequently dotted with brown in fore wings, especially along cubitus. Antennæ short, not reaching beyond middle of thorax; pronotum slender, narrowed in front, this and the rest of thorax with long white hairs, abdomen with short white hair; legs with some long white hairs and black bristles. Fore wings broad below stigma, barely acute at tips, cells of wing small and irregular; radial sector seven branched before stigma; costal area broad, the cells narrow.

Expanse forewings 43 mm., hind wings 47 mm., abdomen long 13 mm.

From Port Darwin, Australia 20 April (Dodd.)

Formicaleo dispersus n. sp.

On the same general plan as *F. septus* and *F. bistrigatus*, but no dark stripes in front wings instead of which are about twenty small dark spots in the area of the stripe of *F. septus* toward the hind margin, and in hind wings is a stripe as in *F. septus* but its apical part broken up into small spots. The head is yellow, a large black spot on front and upper face; antennæ pale on basal part, brown

toward tip; pronotum pale yellowish as also thorax, abdomen rather darker on sides and near tip. Legs pale, unmarked, black bristles; spurs as long as joint I, 5th joint as long as rest together. Wings of general shape of *F. septus*, and similar in venation, seven cross-veins before origin of radial sector in fore wings, one in hind wings; from end of anal vein there is no vein bending up and outward as in *F. bistrigatus*, in this respect like *F. septus*.

Expanse 54 mm.; abdomen long 17 mm.

From Port Darwin, Australia, 13 March (Dodd).

Formicaleo marginalis n. sp.

Pale yellowish; a broad black stripe through antennal region from eye to eye; vertex with two black submedian spots, and a median spot behind them; antennæ pale brown; pronotum with two dark spots on front margin and a stripe behind each of them to the hind border; thorax striped with dark, a submedian pair in front reaching to middle of mesothorax, a lateral one just above wing, and a short pair on metathorax, and a dark spot over base of wings; pleura with some black spots, mostly on lower parts; abdomen blackish, with short white hair; legs pale, with black bristles, and short black hair. Wings unmarked, except at posterior margin near tip of both pairs where the margin is infuscate for about one-third the way from tip to base; venation yellow, subcosta interruptedly black in both wings, and some dark dots on cubitus in fore wings. Venation similar to *F. bistrigatus*, a vein bending upward and outward from end of anal vein in fore wings, seven cross-veins before radial sector in fore wings, one in hind wings. Pronotum rather slender, narrowed in front; legs short, tarsal joint I about as long as II plus III, much shorter than V, spurs a little longer than first joint.

Expanse 43 mm., abdomen long 13 mm.

From Kuranda, Queensland, Australia, March, (Dodd).

Formicaleo septus Gerst.

Port Darwin, latter part March through April; also at Kuranda, March.

Myrmeleon pictifrons Gerst.

Port Darwin; common, 10 to 21 April; and also 3 September; Mid-Queensland (Perkins).

Myrmeleon uniseriatus Gerst.

Port Darwin, 9 September; Mid-Queensland.

Myrmeleon croceicollis Gerst.

Kuranda, March.

Acanthaclisis fundatus Walk.

Kuranda, March (Dodd); Mid-Queensland, (Perkins).

Acanthaclisis subtendeus Walk.

From Kuranda, March (Dodd).

THE ANATOMY OF THE LARVA OF CECIDOMYIA RESINICOLOIDES WILLIAMS.

By Francis X. Williams.

In the January number of Entomological News, Vol. XX, 1–8, 1909, I described this midge in its egg, mature larval, pupal and imaginal instars, and gave a brief biological report on it. The curious habit of the larva in living in a mass of exuding resin might be expected to have brought about some adaptive modifications of its structure, especially perhaps of its tracheal system. It is for this reason particularly that the attempt has been made to study the larval structure in detail. As much of the anatomy of the larva is described here as could be worked out in a limited time, and although over a hundred larvae were examined and dissected, the results are far from complete. Considerable difficulty was encountered in tracing out the various systems of the larva, and the writer has deemed it best to omit the doubtful things and to declare only those facts which were made manifest over and over again by the examination of a large number of specimens.

The work embodied in this paper was done in the entomological laboratory of Stanford University.

EXTERNAL ANATOMY OF THE LARVA.

Head, Pl. I, Figs. 1 and 2. The head is very small and imperfectly developed. Its brownish-black chitinized portion consists of a broad irregular ring from which a pair of prong-like rods project well into the supernumerary segment. These rods diverge posteriorly, are more heavily chitinized than the ring, and have muscles attached to them that run from the body wall. The antennae are short, conical, obscurely two-jointed processes placed well above the opening of the mouth. Ratzeburg and L. Defour believe these processes are palpi, but Osten Sacken as well as Laboulbene and Perris, from the position of these organs, consider them rudimentary antennae. I incline to the latter view since they are situated latero-dorsally on the anterior part of the ring and well above the mouth opening. This latter consists of a soft, fleshy swelling taken by Ratzeburg for the labium.

Breastbone, Pl. I, Fig. 3. Ventrally on the posterior half of segment I, and situated in a sort of fold is the "breastbone,"

also known as the "sternal spatula" or "anchor process," an organ said to be peculiar to the *Cecidomyidae*. This is a brownish chitinized process varying somewhat in shape, but usually widest at the extremities, slightly constricted at or near its middle and at the caudal end, and somewhat incised anteriorly where a small portion of it projects beyond a transverse fold. The caudal extremity is concealed under the posterior fold of segment I. The anterior incised portion of the spatula is somewhat scooped out, and the more heavily chitinized central axis sends out a ridge on either side of this depression. Otherwise the whole piece may be quite uniformly chitinized. A lateral view of this organ shows that it follows the curved outline of that part of the segment in which it lies.

The use or the homology of the "breastbone" has been a subject of some speculation. Giard (8) says that some of these Cecidomyid larvae have the power of leaping, using their well developed spatula and terminal corneus papillae for this process, and in this wise: the larva bends itself almost into a circle, and hooking together the breastbone and papillae breaks the connection thus formed and the spring occurs. In the species referred to by Giard however the spatula is well muscled, strongly chitinized, projects well externally, and the corneus papillae are developed. The advantage gained by this faculty of leaping is, according to Giard, the assurance of the dissemination of the species, which in turn insures an abundant food-supply and therefore the successful perpetuation of the species. The larvae of *Diplosis loti* and *jacobeae*, cited as examples by him as having this leaping power, are gregarious and would not leave enough food for their descendants if they were not thus motile. This theory does not seem adequate inasmuch as the adults look after the food-supply for their progeny, and being active and winged, would have no difficulty in finding another suitable plant on which to oviposit. The motile habits of the larva brought into play just before pupation would indicate a search on the part of the insect for a proper place for pupation, the pupa being formed underground and probably at no great distance from the abandoned food-plant. In *C. resinicoloides* the spatula is not well developed, projects but slightly anteriorly, and the posterior corneus papillae are absent, also as the insect lives both in the larval and pupal stages in pitch, the breastbone could hardly be used as a locomotor organ. In fact it does not appear to be con-

nected with any muscles. Owing to the medium in which the larva lives, it is possible that it has lost this power of leaping by the degeneration of the organs so well developed in the saltatorial Cecidomyid larvae. Locomotion in the larva of *C. resinicoloides* is chiefly, if not wholly, accomplished by the extension and contraction of its spiny segments, with the possible assistance of the pseudopod-like processes.

Another theory advanced to explain the use of the breastbone is that it is used as a perforator (17). It could thus be used in some gall-forming species which pupate outside their gall, to force an exit therefrom. L. O. Howard (11) refers to a view proposed by Enock and sustained by Marchal according to which the spatula is used to reverse the position of the larva in the puparium. In the case of *C. resinicoloides* this last theory might apply, but it seems more probable that the spatula is used in making the cocoon, in pushing out a space in the resin, and forming the thin, convex cocoon cap. Inasmuch as, according to Giard, the spatula is only fully developed in the last moult, it is quite evident that this organ is intimately associated with the prepupal actions of the larva. Osten Sacken says (14): "If the supplementary (14th) segment be considered as a part of the head, this breastbone might be taken for the mentum, in analogy to the horny mentum of the larvae of the *Tipulariae*."

Pseudopods. These are rounded, somewhat nipple-like processes, most prominent on the thoracic segments and usually in double pairs on the segments. Segment I has a pair on each anterior side of the spatula and bordered anteriorly by the imaginal leg discs; segments 2 and 3 have each a more prominent double pair, transversely arranged in the middle of the segments and likewise bordered anteriorly by the leg discs, those of the wings being lateral; segment 4 has an inconspicuous pair of pseudopods; segment 10 some indistinct protuberances; while on segment 11 are a pair of rather widely separated protuberances anterior to the anal slit. The last or 12th segment is terminated by two conical projections bearing a bristle at their apices.

Spiracles. There are nine pairs of spiracles, normally situated, one on the first thoracic segment and one each on segments 4–11. The last pair is placed apparently on the last segment, but Osten Sacken (14) has pointed out that this segment is in reality the 8th abdominal, the 9th being in *C. pini* and *C. pini-inopis*, (the latter being considered a synonym of *C. resinicola*) unusually

small and concealed under the 8th abdominal segment. The spiracles are horny, conical projections placed somewhat above the lateral line, especially on segment 1. The anal spiracles are far larger than the lateral ones, and are of most importance to the larva. They are truncated conical, with four stout spines. No young larvae were examined, but Eckel (5) says of the related *resinicola*: "The tracheal system undergoes no change with the larval growth except the odd development about the anal spiracles." In the young *resinicola* larva each terminal spiracle is a long horny tube, whereas in full-grown specimens they resemble those of *resinicoloides*. The 3rd thoracic segment has no spiracles although the tracheal tube is present here and well developed. Eckel has noted this in the eastern species.

Hairs and Bristles. These may be divided into two classes: (1) longer sparse hairs; (2) shorter numerous bristles. Those of the first class are, as far as could be ascertained, present on all but the supernumerary segment. On segments 4–10 are two larger hairs situated one below the other, the first close to the base of the spiracle. On segment 11, laterally and just below the spiracle is a large hair. On segment 12 are two apical hairs already referred to. These hairs, commonly near the spiracles, may assist in keeping the latter clear of the soft resin in which the larva lies.

The bristles* are arranged in transverse rows forming long patches on the dorsal and ventral surface of the body and thinning out laterally. Dorsally these bands are on the anterior portion of segments 2, 3, 4, 5 and 6, and on the posterior part of segments 8, 9, and 10. The band is heaviest on segment 4 where a blank space cuts out a broad mesal notch on its posterior border. On segments 2 and 3 the band is broad and almost divided by a transverse space, and on segment 5 is further reduced to three patches. The patch on segment 6 is almost obsolete. These bristles point posteriorly while the simple bands on segments 8, 9 and 10 have them pointing anteriorly.

Ventrally the bristle rows are not broken up but are simple, and are present on the anterior part of segments 2, 3, 4, 5, 6, 7, 8 and 9 where they point posteriorly and on the posterior portion of segments 4, 5, 6, 7, 8, 9, 10 and 11, where they point anteriorly. These rows pointing forward thin out anteriorly, and on seg-

* Illustrated in Ent. News, XX, Jan., 1909, Plate I.

ment 4 are quite small and inconspicuous, whereas the sets pointing backward become thicker anteriorly. We see then that these rows of bristles are heaviest at either end of the larva and absent or imperfectly developed along the middle of the body, there being a gradual transition from the posterior—to the forward—pointing bristles. The bristles thin out laterally and are more numerous on the venter than on the dorsum.

Although the larva is not an extensive traveller, it is nevertheless quite active and moves about considerably within the limited space of the resinous mass in which it lives. It cannot survive very long when completely submerged in the gummy exudation, but lives with its anal spiracles at the surface of the mass or in a hollow therein, while its mouthparts are in close proximity to the abraded cambium. It must also turn itself around in its cocoon before pupation. It was observed that the posterior portion of the larva is usually more extended and the cephalic end often more contracted. When the larva desires to advance, its anterior segments are extended, thus exposing the strong rows of backward-pointing bristles, while the hinder end is somewhat drawn in, thus concealing its bristles, and, by contracting and expanding the anterior segments the desired movement can be obtained. It would not seem of so much importance that the larva move its whole body backwards, but that it extend its caudal spiracles to an opening for air is quite imperative. Thus it could firmly anchor its cephalic end to a desired spot, and by means of the forward-pointing bristle rows extend its spiracles to the surface. By sufficient contraction the rows of bristles at one end could be completely concealed and those of the other end fully exposed and brought into play. The pseudopods may also assist in the movements of the larva.

INTERNAL ANATOMY.

Tracheal System. Pl. VI, Figs. 4 and 5. This was very carefully worked out, the tracheal arrangement being followed to the finest ramifications. As in other insects it consists of longitudinal trunks connected with the spiracles by lateral branches. Figs. 4 and 5 of plate VI shows this system from a dorsal and ventral aspect, of a larva submitted to some pressure under a coverglass. It consists of a pair of longitudinal dorsal trunks beginning at the spiracles of segment 1 and terminating in the caudal spiracles of segment 11. At G, Fig. 4, a stout branch is

sent ventrad, which divides almost immediately, the one branch proceeding to the head while the other, bending posteriorly, supplies the brain and sub-œsophageal ganglion. This posterior branch is F_1, in Plate VI, Fig. 4.

The two dorsal trunks are connected with the spiracles by short branches and are joined to each other in segments 4–9 and 11 by cross tubes, that of segment 11 being quite stout while the rest are slender and send out two re-dividing branches. These cross-tubes usually lose their striated appearance at their middle, appearing composed of two tubes fused together by a pair of sponge-like knobs. In segment 10, there is no fusion, the tubes remaining separate. Fig. 6, E_{10}, Pl. VI, shows a condition observed in two larvae in which the left branch is quite swollen basally, which perhaps was the normal thickness of both tubes, throughout before atrophy occurred and the tubes separated. The fact that in *C. resinicola* there are complete cross tubes in segments 4–11 would appear to strengthen this view. Furthermore it will be noticed that in *C. resinicoloides* the cross tube in segment 11 is quite stout and may substitute in a measure for the tubes in the above segment. Ramifying tracheae are apparently not so necessary in the last few segments.

The transverse lateral tubes D_3—D_{10}, Fig. 4, terminate in the spiracles except in segment 3 where there is no spiracle, in which case the tube disappears near the body surface. They are connected with one another either by the lateral longitudinal system through the short tube R_3, R_4, etc., as in segments 3–8, or they may run directly through the former, as in segments 9 and 10. This arrangement, however, is frequently asymmetrical.

The lateral longitudinal trunks arise from the dorsal ones in segment 2, Fig. 4, A_2, Pl. VI, and terminate as free branches in segment 10, C_{11}, Fig. 4, and apparently correspond to the ventral tubes as illustrated by Eckel (5), but differ widely from the latter in that they do not join the dorsal trunk posteriorly. They send out many branches F_2, F_3, K_4, K_5, etc., but the arrangement of these is not always constant. The primary function of the more anterior of these branches is to aerate and support the nervous system, that of the more posterior ones to supply the Malpighian tubules.

The ventral longitudinal system Fig. 5, Pl. VI, arises from the main dorsal one close to the anal spiracles in segment 11, and proceeding anteriorly commences ramifying in the middle of

segment 8, where it turns dorsally, closely following the Malpighian tubes to which short branches are sent.

Circulatory System. This system owing to its transparency and delicacy was quite difficult to follow, and so a detailed description of it cannot be presented. The dorsal vessel is a thin-walled, transparent tube which arises in front of and below the brain, and proceeds obliquely upwards until it meets the body wall in the posterior part of segment 4 where it is secured by the suspensorium. Thence it runs along the dorsum extending at least to the posterior transverse tracheal tube. It is divided into chambers and the valvular orifices (ostia) on either side open and close inwardly. The dorsal vessel pulsates especially in its anterior portion where there are several orifices. On each side of the heart in the middle of segment 4 is a strip of loose pericardial cells which proceed posteriorly, closely following the vessel.

Alimentary Canal. Pl. VII, Fig. 1. The alimentary canal consists of the long slender œsophagus D, the larger scarcely differentiated fore- and mid-stomachs (proventriculus and ventriculus) G, the slender and much curved ileum or small intestine I, the colon K, and the rectum L. A pair of long, recurved salivary glands C. F. open into the mouth, and two Malpighian tubules H, likewise recurved, are fastened to the fore part of the ileum. The whole system is supported chiefly by the tracheæ.

Lying above the œsophagus and salivary glands and extending well beyond the rods of the head skeleton is a large blind sac, S, Figs. 1 and 2, Pl. VI, which probably opens into the mouth. It contains in its middle a curious, dark purplish-brown object, A, Figs. 1 and 2, Pl. VI, which is lobed anteriorly, and posteriorly where it becomes semi-translucent and breaks up into small granules. This object is evidently the "*point oculiforme*" of Giard (8), who noted it also in a Cecidomyia, but what its function is he does not state. The large blind sac is apparently not muscular, though it is possible that it may serve as a food reservoir. The "*point oculiforme*" suggests a strainer of some sort, especially if the sac were muscular. The œsophagus extends to the end of segment 3 as a very slender and delicate tube, and is chitinized within the rods of the head skeleton, C, Fig. 2, Pl. VII, and Fig. 6, Pl. VII.

The large, straight, muscular stomach extends from the 4th to the 8th segment inclusive, and its cellular coat is made up of

more or less regular longitudinal rows of large protruding cells. The whole canal, including the salivary glands and the Malpighian tubules is clearly visible through the larval body wall.

In the posterior portion of segment 8 the slender ileum arises abruptly from the thick ventriculus as a curved and folded tube. Its cellular wall consists of several rows of large cells distinct in the anterior orange portion, less so in the whitish translucent middle part, and disappearing in the slenderer hinder end, which opens into the delicate grayish colon. The rectum is a rather colourless tube of considerable length terminating in the anus on segment 11.

The extreme hind part of the canal probably functions but little, except perhaps when the larva is near pupation. It was not seen to contain any waste matter, and if the larva was submitted to considerable pressure under a coverglass no excrement would be discharged.

Glandular and Excretory Appendages of the Alimentary Canal. The salivary glands are of large size and extend along each side of the ventriculus to the middle of segment 6 where they recurve dorsally and proceed to the anterior end of segment 5, being fastened to the ventriculus at that point. The larger posterior portion of the glands are glassy white and of moniliforme aspect, with several rows of large glandular cells containing large nuclei. At about the middle of segment 3 the glands become narrower, lose their glassy, large-celled appearance, and twisting spirally downwards, then upwards, dilate abruptly into granular ampullae of a pale yellowish-white color. These are three in number, two larger posterior ones and a single inconspicuous anterior swelling. From this latter point the glands taper gently, and at about the posterior border of the supernumerary segment give place to the tracheoid ducts. These are short slender tubes and join to form the common duct, B, Fig. 2, Pl. VI, a short distance within the chitinous rods of the head skeleton.

Whether the secretion of the salivary glands of the larva produces an irritation in the plant tissue thereby causing a flow of resin, or whether "the twistings of perhaps a dozen spiny-skinned larvae smooth out a round cavity" (in the resin), "the irritation causing a constant supply of fresh resin," to use Eckel's own words as regards *C. resinicola*, is a difficult thing to determine. Giard (9) thinks that the "zymase" secreted by the salivary

glands of the Cecidomyid larva determines the gall. No gall is formed in the case of the pitch-inhabiting midges, but the salivary secretion in this case might well stimulate and maintain the resinous exudation.

Attached interiorly to the second ampulla of the salivary glands and stretching in a curve across the brain which it overlies very closely is a curious, loose ill-defined structure of granular appearance, F, Fig. VII, Pl. 2, and containing brown patches, especially towards the bases. This I believe is Weismann's "cell chaplet," which he defines thus: "It consists of a string of large cells closely united which hangs like a garland, free in the body cavity. Its two ends are connected with the salivary glands," etc. What its function is remains to be ascertained.

The Malpighian tubules are of a deep orange color and arise from the anterior end of the ileum immediately where the latter is joined to the ventriculus by a delicate membrane. The arrangement of these two tubules with regard to the ileum and colon is not symmetrical since the left one follows rather closely those two divisions of the proctodæum, while the right tubule is quite free. Fig. 5, Pl. VII shows the left tubule in its relation to the proctodæum. Arising from the ileum each tube proceeds dorsally but not quite in symmetry as the right tube bends anteriorly and outwardly while the left first curves somewhat posteriorly, P, Fig. 1, Pl. VII and then follows the common course. Each tube is closely appressed to the ventriculus to which it is slightly fastened and proceeds anteriorly past the middle of segment 7. Here however the left one by reason of its posterior bend does not reach quite so far forward as its mate, but terminates slightly farther posteriorly and ends somewhat beyond the middle of the colon. Both tubes run along the ventral tracheal trunks in their terminal portions.

Giard says (10):—"In all the larvae of the Cecidomyidæ which I have studied, these tubes, two in number are united into an elegantly recurved handle, and open near the anus, the proctodæum being excessively short." In *C. resinicoloides* the tubes end freely, as we have seen, and the proctodæum, if extended would probably at least be as long as the rest of the alimentary canal.

It may be well said here that the alimentary canal (and its appendages) of *C. resinicoloides* much resembles that of *Diplosis buxi* illustrated by Berlese (2).

Organs of Reproduction? At about the termination of the Malpighian tubules, and below the same is a pair of elongate, fusiform, transparent bodies terminating anteriorly and posteriorly as slender tubes. These bodies were not observed in all the larvae examined. They are probably the developing reproductive organs.

Nervous System. Plate VIII, Figs. 1 and 2. The nervous system is more specialized than in many other dipterous larvae, in that there is considerable cephalization of the ganglionic chain. This chain is composed of ten distinct ganglia, exclusive of the sub-œsophageal one, and extends from the middle of segment 2 to the middle of segment 4. It is supported chiefly by the converging branches of the lateral longitudinal tracheae, while the brain is kept in place and aerated largely by the stouter pair of tracheal branches, F_1, which arise from the main dorsal system.

The brain or supra-œsophageal ganglion consists of two lobes of larger size than the rest and broadly joined to the sub-œsophageal ganglion, the commissure not being apparent. The œsophagus passes between these two ganglia, as probably also the dorsal vessel, the salivary glands running on either side. At least one pair of nerve cords from the brain, and two or more from the sub-œsophageal ganglion proceed anteriorly, and each of the ganglia of the chain sends out several nerves, some of which run along the lengths of the supporting tracheae. The last ganglion of the chain is more elongate than the others.

Very little could be made out of the sympathetic nervous system, and the paired ganglia, C, Figs. 1 and 2, Pl. VIII, arising posteriorly from the lobes of the brain are all that I feel sure of.

Musculature. The muscles were not studied though it was observed that they were numerous and well developed, a condition quite necessary in such a restless insect. Several muscles are fastened to the chitinous prongs of the head skeleton, and a number of large muscles radiate from the caudal cleft, being fastened to the body wall. Thus the larva is enabled to retract quickly its caudal end into the resinous mass if disturbed.

Adipose tissue. This is very well developed, so much so indeed that it obscures in a great measure the different visceral systems. The fat body is of a dirty yellowish-white color, and consists of a loose network of lobes with long meshes, and is continuous throughout the body, thickest below the middle, thence tapering to either extremity, extending anteriorly to the base of the

first pair of spiracles, and posteriorly to near the anus. It is circumscribed and largely supported by the tracheal system. Some time before pupation this fat tissue loses much of its compactness, becoming more or less watery in appearance and assumes a reddish color.

Imaginal Discs of Wings and Legs. Plate VIII, Figs. 6 and 7. These are easily seen in large full-fed larvae where they appear as more or less circular discs attached to the body wall.

The wing-buds, Pl. VIII, Fig. 7, A_2A_3, are larger than those of the legs, lie very slightly above the lateral line of the body, and are supplied with branches of the lateral and dorsal tracheae. Both wing- and balancer-discs arise from about the middle of their respective segments, ending posteriorly in a lobe and tapering anteriorly into the body wall.

The three pairs of leg discs, Fig. 6 A_1, A_2, A_3, are situated on either side of the ventral line and are more distinctly circular in outline than the wing discs and more strongly and completely cut by an inner ring. They are supplied by small branches of the lateral tracheae.

BIBLIOGRAPHY.

1. **Aldrich, J. M.** (1905). Catalogue of N. A. Diptera, pp. 151–152, 160.
2. **Berlese, A.** (1906). Sistema Ghiandolare, Ghiandole Confinate, (Gli Insetti, I, p. 523).
3. **Comstock, J. H.** (1879). Diplosis resinicola, (Rept. Dep. Agr., 1879, p. 256).
4. **Cannon, W. A.** (1900). A Botanical Study of the Gall formed by Diplosis pini-radiatae, (Am. Nat., XXXIV, No. 406, pp. 801–810.)
5. **Eckel, L. S.** (1903). The Resin-Gnat Diplosis and Three of Its Parasites, (Ent. News, XVI, pp. 279–284).
6. **Felt, E. P.** (1903). C. resinicola, (N. Y. State Mus. Memoir 8, II, pp. 410–413.)
7. **Felt, E. P.** (1903). C. pini-rigidae, (N. Y. State Mus. Memoir 8, II, pp. 423–425).
8. **Giard, A.** (1893). Note sur l'organe appelé Spatula sternalis chez certaines larves de Cecidomyes. (Bull. Ent. Soc. France, Feb. 22, 1893).
9. **Giard, A.** (1893). Sur un genre nouveau et une espece nouvelle de Cecidomyidæ (Drisina glutinosa), (Bull. Soc. Ent. France, Dec. 27, 1893).

10. **Giard, A.** (1893). Sur less tubes de Malpighi de les larves de Cecidomyes, (Bull. Ent. Soc. France, Feb. 22, 1893).
11. **Howard, L. O.** (1898). The Hessian Fly in U. S., (Bull. 16, Dep. Agr., Div. Ent.)
12. **Kertesz, C.** (1902). Catalogus Dipterorum, II, pp. 116–117.
13. **Mik, Jos.** (1897). Einiges uber Gallmucken, (Wein. Ent. Zeit., XVI, pp. 290–292.)
14. **Osten Sacken** (1862). On the Habits of the Cecidomyidæ, (Mon. Dip. N. A., Pt. I, pp. 179–198.)
15. **Osten Sacken** (1871). Biological Notes on Diptera, (Trans. Am. Ent. Soc., III, pp. 345–346). D. resinicola, etc.
16. **Packard, A. S.** Diplosis resinicola and Pini-rigidae, (5th Rep. U. S. Ent. Comm., 1886–1890, pp. 797 et seq.)
17. **Sharp, D.** (1901). Use of Spatula in Cecidomyidæ, (Camb. Nat. Hist. Ins., Pt. II, p. 460).
18. **Snow, W. A.** (1900). The Destructive Diplosis of the Monterey Pine, (Ent. News, XI, pp. 489–494).
19. **Townsend, C. H.** (1893). Notes on Some Cecidomyiidæ of the Vicinity of Wash., D. C., (Proc. Ent. Soc. Wash., II, pp. 389–390). D. resinicola, etc.

EXPLANATION OF PLATES.

All figures greatly enlarged.

PLATE VI.

FIG. 1. Dorsal view of head skeleton; S. blind sac; A, point oculiforme; O, œsophagus; B, salivary duct; N, nerve.

FIG. 2. Lateral view of head skeleton; S, blind sac; A, point oculiforme; B, tracheoid duct; O, œsophagus; N. nerve.

FIG. 3. Sternal spatula; A. A, A, dorsal view; B, lateral view.

FIG. 4. Dorsal view of tracheal system of mature larva; A_1—A_{11}, dorsal longitudinal trunk; B_{12}, ventral longitudinal trunk; C_2—C_{10}, C_{11}, lateral longitudinal trunk; D_3—D_{10}, lateral transverse tubes to spiracles; E_4—E_{10}, E_{11}, cross tubes; F, F_1, F_2—F_4, branches to nervous system; K_4, K_5, branches to nervous system; G, branch from dorsal trunk; H, branch to head; R_3, R_4, R_5, connecting branch between C and D; M, head; S, supernumerary segment.

FIG. 5. Ventral view of tracheal system of mature larva, lettering same as in Fig. 4, B_8, dorsal turn of ventral longitudinal trunk.

FIG. 6. Aborted cross tubes of Seg. 10.

PLATE VII.

FIG. 1. Dorsal view of alimentary canal of mature larva; A, head; B, blind sac; C, ampullae of salivary glands; D, œsophagus; E, Weisman's cell chaplet; F, large-celled portion of salivary glands; G, ventriculus; H. Malpighian tubule; I, ileum; J, ventral longitudinal trachea; K, colon; L, rectum; M, anus; P, posterior bend of left Malpighian tubule

FIG. 2. Head skeleton and portion of salivary glands; A, antenna; B, head skeleton; C, œsophagus; D, common duct of salivary glands showing tracheal character; E, ampulla of salivary glands; F, Weisman's cell chaplet.

FIG. 3. Sagittal section through larva; A, adipose tissue; B, muscle; C, alimentary canal; O, œsophagus; I, ileum; P, Malpighian tubule; M, M_1, salivary glands; H, heart; S, blind sac.

FIG. 4. Cross trachea in segment 11 showing central spongy mass.

FIG. 5. Lateral view of proctodeum; A, posterior end of ventriculus; B, ileum; C, colon; D, rectum; E, anus; F, Malpighian tubule; L, L_1, slender portion of ileum; O, point of origin of Malpighian tubules.

FIG. 6. Chitinized portion of anterior end of œsophagus.

FIG. 7. Dorsal view of anal spiracles, 12—last segment.

PLATE VIII.

FIG. 1. Dorsal view of nervous system; A, sub-œsophageal ganglion; B, brain; C, one of the paired ganglia of the sympathetic system; F, trachea feeding brain and sub-œsophageal ganglion.

FIG. 2. Lateral view of nervous system; lettering as in figure 1. T. trachea.

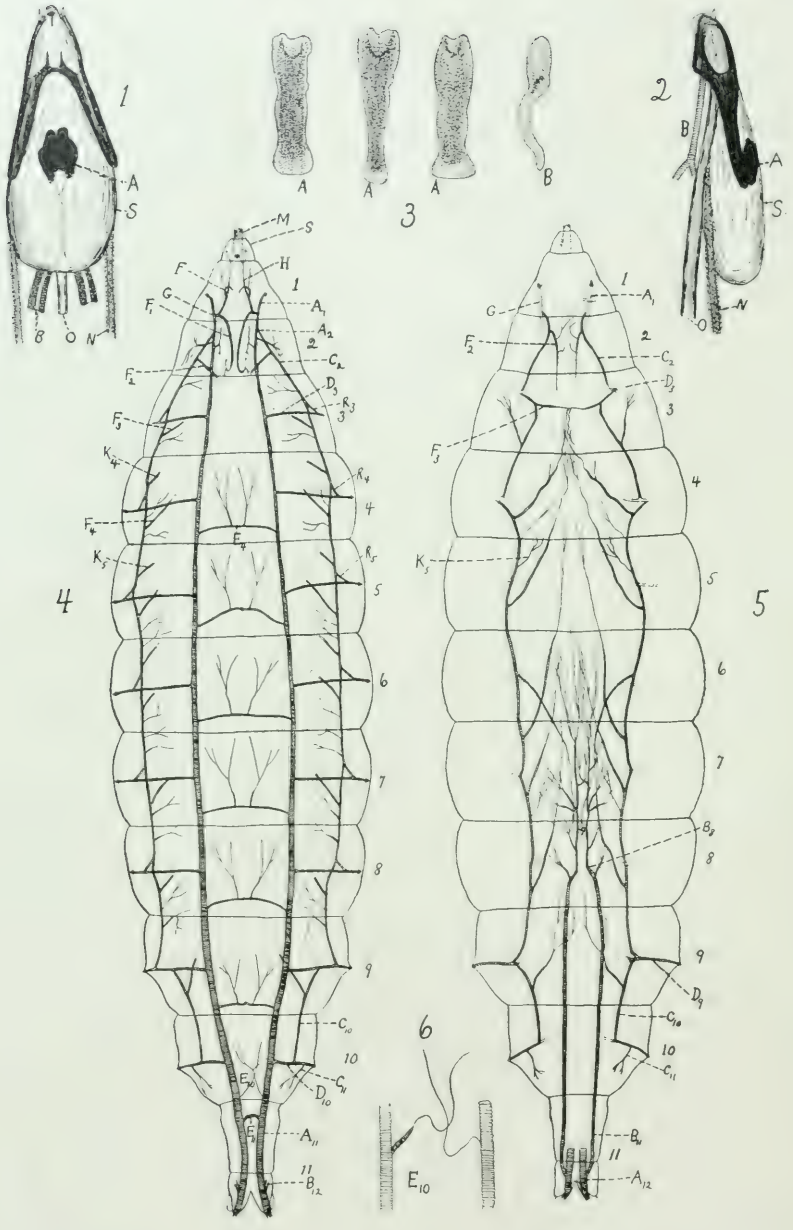
FIG. 3. Cross section through posterior portion of larva; A, adipose tissue; B, muscle; C, ventriculus; H, heart; M, Malphigian tubule; L, L_1, slender portion of ileum corresponding to L, L_1, of Fig. 5, Plate VII.

FIG. 4. Cross section through ventriculus showing epithelial cells.

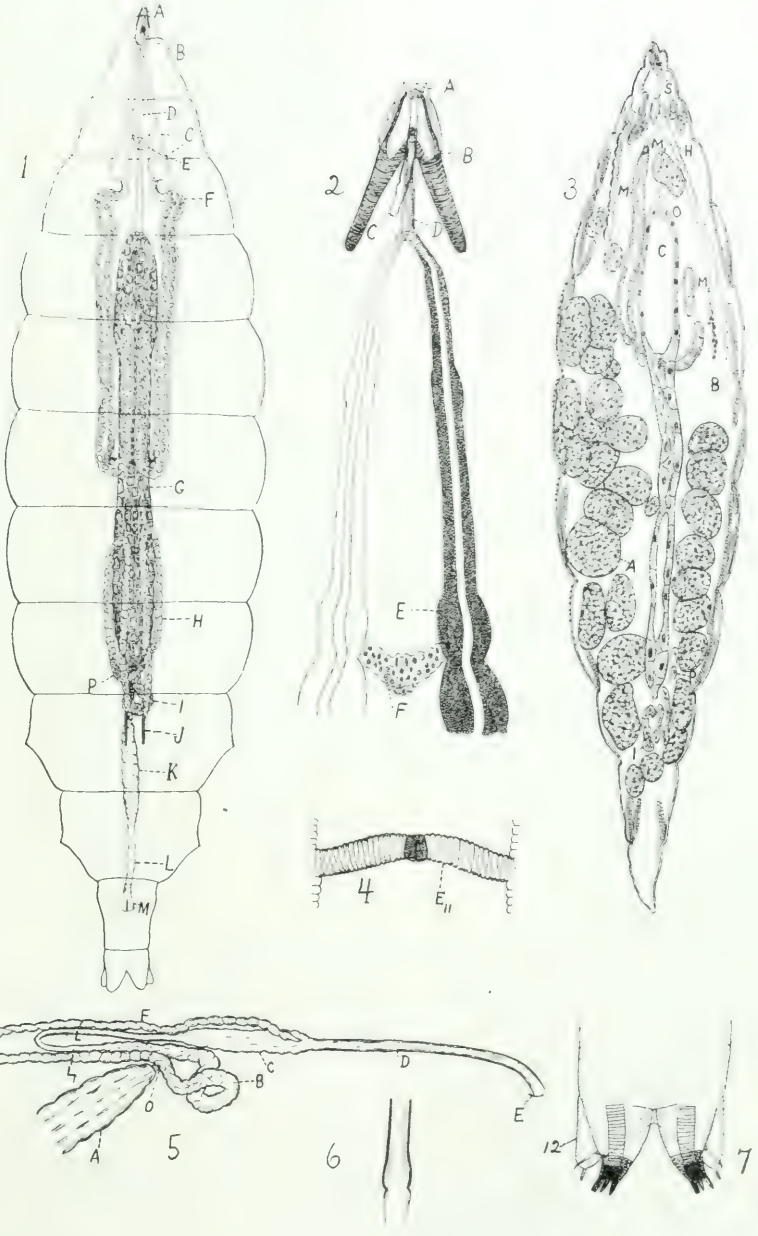
FIG. 5. Cross section through anterior portion of larva; A, adipose tissue; B, muscle; C. ventriculus; M. salivary glands; H, heart; F, pericardial fat cells.

FIG. 6. Ventral view of anterior portion of larva (portions of segments 1, 2 and 3) showing imaginal leg discs, A_1, A_2, A_3; B, dorsal longitudinal trunk of tracheal system; C, lateral longitudinal trunk; D, tracheal branch feeding brain, this is F_1, Fig. 4, plate VI.

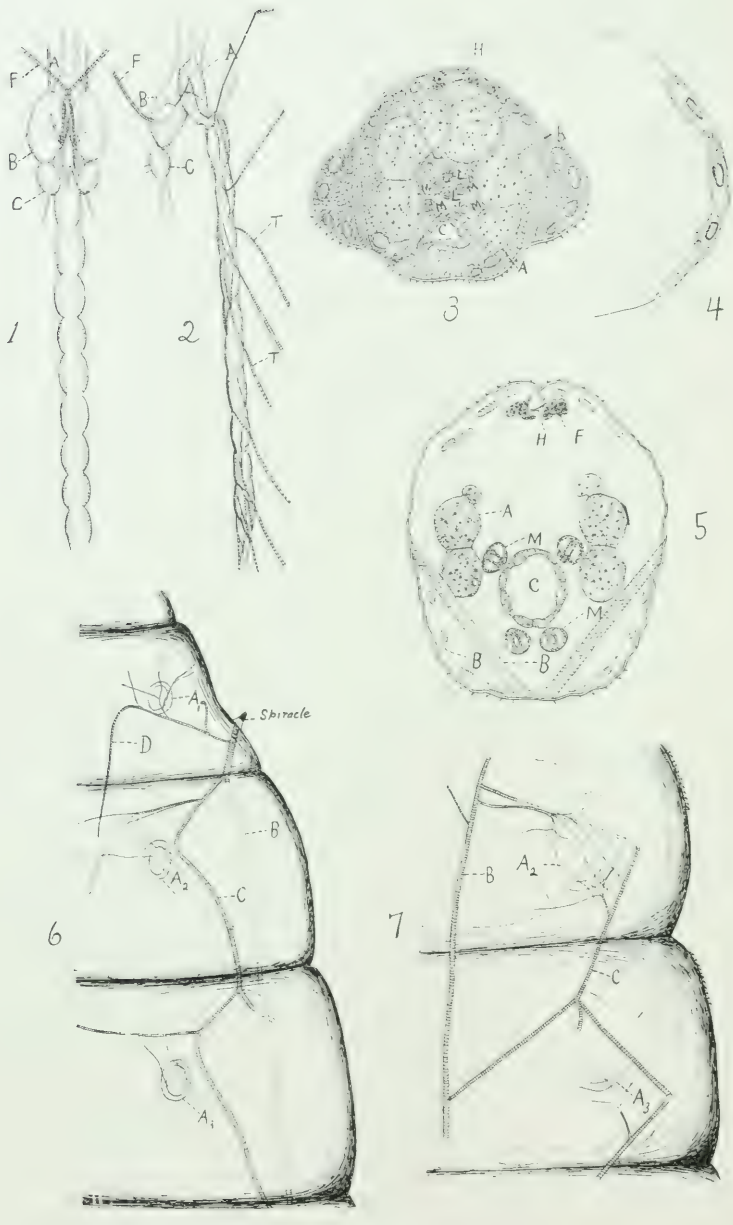
FIG. 7. Dorsal view of portion of segments 2 and 3, showing imaginal wing discs, A_2 and A_3; B, dorsal longitudinal trunk; C, lateral longitudinal trunk.


1
A
S
B
O
N
A
A
A
B
3
2
B
A
S
N
O
4
M
S
H
F
G
F_1
A_1
A_2
C_2
D_3
R_3
F_3
K_4
R_4
F_4
E_4
K_5
R_5
C_{10}
E_{10}
C_{11}
D_{10}
A_{11}
B_{12}
5
A_1
G
F_2
C_2
D_3
F_3
K_5
B_8
D_9
C_{10}
C_{11}
B_{11}
A_{12}
6
E_{10}

F. X. Williams.



F. X. Williams.


F
A
B
C
1
F
A
B
C
T
T
2
H
A
M
C
3
4
H
F
A
M
C
M
B
B
5
A1
Spiracle
D
B
A2
C
6
A1
B
A2
C
A3
7

F. X. Williams.

SOME NEW FACTS ON THE BIONOMICS OF THE CALIFORNIA RODENT FLEAS.

M. Bruin Mitzmain, B. S.,
University of California.

The thorough investigations which the United States Public Health and Marine-Hospital Service are at present undertaking in suppressing bubonic plague in California presented the writer with an opportunity to study the parasites associated with the transmission of the disease among rodents.

In this contribution we have not taken into account the factors involved in the epidemiology, but have restricted the scope of the paper to a discussion of the general habits and transformations of the California rodent fleas. Many of the observations on the bionomics of the fleas are quite different from those recorded by the investigators of the English Plague Commission in India. This is due in a measure to difference in climatic conditions, to which fleas as a rule are easily influenced; and the difference in the species of flea. The English workers confined their experiments to one species, namely, the *Loemopsylla cheopis* Roth. We have considered the rodent fleas generally, giving most attention to the squirrel flea *C. acutus* Baker.

FLEAS IN RELATION TO THEIR ENVIRONMENTS.

We have made an effort to rear fleas in the laboratory by attempting to duplicate conditions found to exist in nature. The human flea, *P. irritans* Linn, was found to develop very satisfactorily in a medium composed of floor sweepings taken from the cracks in the floor. The squirrel fleas and rat fleas were found to develop well in material taken from the nests of their respective hosts. We have experienced no difficulty in raising these parasites by placing animals covered with fleas in cages with a bedding of sawdust; and the only provision necessary for complete development was the addition of fresh sawdust to prevent the accumulation of too much moisture.

An experiment was made to determine in what media fleas away from the host would survive longest. For this purpose we tested various materials shown in the following table:

LENGTH OF LIFE IN VARIOUS MEDIA.

C. acutus.

Days Removed from Host	Dry Sand with Squirrel Droppings	Moist Sand from Squirrel Nest	Dry sand from Squirrel Nest	Sawdust Moistened with Horse Serum	Dry Sawdust	Moistened Sawdust with Wheat Grains
	* †					
2	5 M. 5 F.	10 F.	10 F.	4 M. 6 F.	4 M. 6 F.	4 M. 6 F.
7	2 M. 5 F.	4 F.	All dead	1 M. 3 F.	4 F.	1 M. 5 F.
9		1 F.		2 F.	2 F.	1 M. 4 F.
10	2 M. 5 F.	All dead		All dead	All dead	1 M. 4 F.
14	1 M. 1 F.					1 M. 3 F.
16	1 M. 1 F.					
17	All dead					1 M. 3 F.
20						3 F.
25						1 F.
26						All dead

*M—Male; †F—Female.

The controls 5 M. 5 F. were all dead on or before the seventh day.

In the medium of moistened sawdust mixed with a few wheat grains it was found that the wheat sprouted in the sawdust and held sufficient moisture to provide a suitable condition for larvae as well as for adults. The mould which formed in a short time did not seem to affect the insect life.

It is seen that the fleas did not fare well in the medium of dry sand. The sand was mixed with clay dust which would rise whenever the fleas hopped in the vial. As a consequence death resulted presumably by stoppage of the spiracles.

It will be seen from a survey of this table that fleas taken from the natural host may be kept alive without food for a considerable time. The medium of moistened sawdust with a few grains of wheat seemed to answer the moisture requirements for flea life.

LOCOMOTION.

The only literature that has come to our notice on the jumping powers of fleas appears in the Journal of Hygiene, 1906, Vol. 6, p. 464. Here we have a note: "It had previously been found that a rat flea could not hop farther than five inches." The species in question in these experiments was the *L. cheopis*, which is found to the extent of 99% on the rats in India.

It seemed desirable to learn the jumping abilities of the common California species. An attempt was made to determine the distance upon a horizontal plane, as well as the height that the insect could jump. In the broad jump a few experiments were conducted with *P. irritans*, the most active of our California fleas. In this species we have found the jumping distance varies considerably with the nature of the container from which the insect is observed, e. g., a foothold of wood enables the flea to jump a greater distance than one of glass. Since the *irritans* is found to predominate on floors of houses, a surface of wood was selected as the footing in our tests. In one experiment, five specimens were permitted to jump at will and the jumps of each were recorded. The mean average of ten jumps of each specimen gave a distance of 7 3–10 inches. The longest jump recorded was 11 inches; this was made by a female. In another experiment, a female, which was starved for five days prior to the test, made four jumps of respectively 10 5–10, 11, 12, and 13 inches; averaging 11 5–8 inches. Thirteen inches was the longest jump recorded on a horizontal plane. A jump of 15 7–8 inches was made downward at an angle of thirty degrees.

This specimen was then permitted to feed fifteen minutes on the arm of an attendant, after which it was carefully returned to the container, and its jumps for five minutes recorded. The longest jump after feeding was 12 inches.

The jumping powers of squirrel and rat fleas were tested in this manner: Three hundred and seventy-five live squirrel fleas (*C. acutus*) and one hundred and fifty live rat fleas (*C. fasciatus* and *L. cheopis*) were placed in two distinct lots in fifteen open specimen vials in a water bath and left undisturbed for two days. At the end of the period, the vials were examined, the water bath and the surroundings being carefully inspected. No fleas could be detected in the water bath or in the vicinity; the fleas in the vials were counted, the original number being present. They were apparently as active as when removed from their hosts. The containers were cylindrical vials 3 3–8 inches in height and 1 3–16 inches in diameter. The same test was tried in open shell vials of the next size smaller (3 1–8 x 1 inch) and the fleas were found jumping into the water bath.

L. cheopis, the rat flea, was tried for its jumping power. It had been previously observed that members of this species were unable to leap out of open shell vials 3 3–8 inches in height. It

was thought desirable to permit the flea greater latitude making the trial fairer and more practical. Twenty fleas (eight males and twelve females) were placed in a rectangular porcelain dish, the dimensions of which were 11 7–8 inches by 7 5–8 inches by $2\frac{1}{4}$ inches deep. A light sprinkling of moist sand was placed in the bottom of the dish to provide a firm footing and the sides of the dish were extended to the height of $4\frac{1}{2}$ inches, enclosing the container entirely by strips of "tangle-foot" paper. At the end of twenty-four hours the dish with the fleas was examined, and it was observed that several fleas had leaped high enough to become entangled on the adhesive paper. The position of these was noted, the distance from the bottom of the pan was measured. The entangled insects were pried off, the sticky material dissolved with alcohol and the insects examined microscopically. Five specimens were collected, two males and three females. The locations on the adhesive paper relative to the base of the dish were as follows:

1 F. $2\frac{1}{2}$ inches	1 F. 3 1-8 inches	1 F. 2 9-16 inches
	1 M. 2 5-8 inches	1 M. 3 1-16 inches

A census of the fleas remaining in the bottom of the dish gave 6 M. and 9 F. showing that none jumped over the surrounding paper, and that all jumping over $2\frac{1}{2}$ inches were embedded in the adhesive paper.

The jumping powers of *P. irritans* were further tested, twenty fleas of this species being placed in a rectangular museum jar, the inside dimensions of which were $2\frac{1}{4}$ x $5\frac{1}{2}$ x $7\frac{3}{4}$ inches depth. The glass lid of the jar was coated with "tangle-foot" and the sides of the jar within two inches of the top were likewise coated, with the same material. The following morning the jar was examined and two specimens were seen embedded in the "tangle-foot" on the lid. The inside height of the jar being $7\frac{3}{4}$ inches from the base gives then this height as the perpendicular jump.

Concerning the fleas ability to walk upwards on glass, we have noted that they cannot climb to any considerable distance. A great number of counts were made, the greatest distance observed being $\frac{3}{4}$ inches. The climb appears very laborious and in all cases the flea dropped to the bottom of the jar after a few efforts.

We have observed the manner in which these insects can find their way about upon their natural hosts. They pilot their paths among the dense hairs, walking on the flat of their tarsi, seeming to shuffle along. When on the animal they seldom hop about,

unless disturbed or unless the host snaps at them or scratches when unusually annoyed. They hop freely when jumping from the animal to the ground or vice versa, or from one host to another. When a flea is cornered, that is, when it experiences difficulty in passing an obstruction, it proceeds like a swimmer using the side stroke. The parasite drops to its side and locomotion ensues by a vigorous sweeping movement of the legs, almost entirely by the use of the hairs and spines, especially through the medium of the powerful spines of the tibia, when it ambles along on the flat side in a striking manner. The spines of the leg seem to be peculiarly adapted for this side motion: it is in this fashion that the nimble parasite manages to become so very elusive. We refer especially to the *P. irritans*. This may be tested by holding a live flea between the thumb and forefinger and unless you chance to be a flea trapper of long and painful experience the ingenious parasite will surely escape.

CONSIDERATION OF COLOR ATTRACTION.

We have a little experimental evidence on the question of attraction of these insects towards color in animals. It is the prevailing opinion that white animals attract the greatest number of fleas. We have to report a few tests of color attraction. The material used in the first experiment was six guinea pigs showing extreme variations of color: three of these were pure white and three pronouncedly dark. These were placed in a large cage, the bedding of which was infested with squirrel fleas. After forty-eight hours the guinea pigs were removed simultaneously and a census of the fleas on the individual animals was made immediately. Fleas and animals were anaesthetized at the same time, the white guinea pigs yielding respectively ten fleas, five fleas, and eleven fleas. The black guinea pigs yielded eleven, seven and four fleas; the last number came from a mixed black and white guinea pig. A summary of the fleas from the three white guinea pigs gave twenty-six fleas, or an average of about nine each; the two dark guinea gigs giving eighteen, averaging nine each, and the black and white giving four fleas, all of which were of the species, *C. acutus*, the squirrel flea.

A second experiment was as follows: Four guinea pigs were placed in a large container, which was swarming with squirrel fleas. After three days the animals were removed as before, and a census of the parasites was taken: one brown and black

guinea pig yielded eighty-nine fleas; another brown and black guinea pig yielded fifty-seven fleas; a pure white guinea pig yielded fifty-seven fleas; and the other white guinea pig yielded sixty fleas. These guinea pigs were kept together in the open vessel under the same conditions of light and temperature.

One experiment was conducted by using guinea pigs as traps for fleas in an infested house. The results shown are relatively meager due to the previous use of adhesive paper for flea trapping. In this test six guinea pigs were permitted to wander for twenty-four hours through the basement of the house. The fleas collected from the guinea pigs were *P. irritans* found on the hosts as follows:

Color of animal	Number of fleas
Black guinea pig	1
White guinea pig	1
Black guinea pig	1
White guinea pig	1
Black guinea pig	0
White guinea pig	0

It is obvious from these experiments that color does not exert the influence generally claimed for it. The white animals are no more attractive to the fleas we have used than are the dark colored ones.

TRAPPING OF FLEAS WITH MEAT AS A BAIT.

An idea prevails that fleas can be attracted and trapped on account of their predilection for the odor of fresh meat. This idea was put to test in an experimental way. On the 23rd day of August, 1909, during a season in the year in which fleas were extremely abundant, a vacant house, which was found to be flea infested, was chosen for the experiment. To give an idea of the abundance of the parasites, two attendants, who had occasion to enter the first floor of the dwelling, remained for the period of five minutes and emerged covered with fleas. Approximately two hundred fleas were taken from their clothing and persons. The materials used for the experiment were twelve sheets of "tangle-foot" fly paper, distributed in pairs among three rooms of the house. One sheet of each pair was supplied with a small fresh piece of cow's liver. Care was taken to distribute the sheets in such a manner that the influence of light would be the same for each pair of sheets in the series. The sticky fly papers were left undisturbed for a period of three days, then collected and examined.

A similar experiment was conducted at a later date, December 5th, 1909, when San Francisco dwellings were still flea infested. The sheets of fly paper were left in the basement of the house for twenty-four hours. The fleas in both experiments were removed by dissolving the "tangle-foot" in alcohol. The parasites which were all identified as *Pulex irritans*, were distributed on the sheets as follows:

Total number of fleas trapped.

	Experiment 1		Experiment 2	
Pair	Adhesive paper with meat	Adhesive paper without meat	Adhesive paper with meat	Adhesive paper without meat
1	0	0	2	4
2	2	2	1	3
3	2	1	6	4
4	0	3	47	49
5	6	12	1	0
6	4	1	4	1
Totals	14	19	61	61

The table shows that according to our experience, though the data is limited, meat used as a bait under the conditions stated does not exert any special attraction for fleas.

COPULATION AND EGG LAYING.

The most prolific of the rodent fleas, *Ceratophyllus acutus* was set aside for studies in mating. The fleas were observed in nature in relation to the host, then microscopically. For the purpose of close observation, a live ground squirrel (Citellus beecheyi) was placed in a mouse jar, where it was kept for a few hours under surveillance. It was noticed that when the animal's body was pressed against the glass that the pelage parted in furrows made by some active objects close to the skin. It was apparent that the squirrel was harboring a large number of active fleas, which occasionally came to view mounted on the hairs of the host.

The attention of the observer was attracted by a number of fleas which appeared gigantic in size. These proved on close inspection to be paired. Approximately 1 to every 3 of the total number of fleas infesting the squirrel appeared thus in copulation. The female of the pair covered almost entirely the body of the

male, which was quite lost to view, only the hind legs projecting beneath the abdomen of the female. The pair in copulation was observed never to feed, moving about as one insect; and anomalous as it appears, the member on the ventral side, the male, contributed no effort in the locomotion during the nuptial wanderings. His fore and middle legs doubled under the sternum, the hind pair extending stiffly as though paralyzed beneath the abdomen, where they were held securely by the tarsal spurs of the female interlocking with the tibial spines of the male.

The locomotory function was accomplished by the female, the front and middle legs of which were used freely in walking; by releasing temporarily the entwining spines of the hind legs she was able to leap at will. In this manner, the female moved about on the body of the host as though unhampered by its anchored mate.

Seven pairs of these fleas were collected from the live squirrel with the aid of a camel's hair brush, placed in cell slides and covered with glass slips. They were observed under the low power microscope, then kept in separate vials, one to several hours until the function was completed.

As observed microscopically, the male adheres to the female by the pseudo-joints of the terminal segment of the antennae. This attached appendage is extended and pendant, interlocking by its hairs the bristles on the ventral side of the second abdominal segment of the female. The hind femora of the latter grasps the male by the head at a point anterior to the antennal groove. The head of the male is held in position between the inner sides of the meta-femora of the female. The tarsal spurs of the female entangle the spines of the hind tibia of the male. The smaller of the pair thus suspended assumes the passive role moving at the volition of the female.

The copulatory act is manifested in the male by the watch-spring like action of the spiral, which, coiling and uncoiling intermittently extends and withdraws the terminal apparatus.

The male claspers are seen on either side of the vaginal groove of the female directly below the anal flap. The male makes a distinct concavity in the caudal portion of the back; with the strong action of the muscle attachments the plate of the penis is made very elastic. The spasmodic pulsations of the curled up abdomen are followed by a current of bubbles passing through the genitalia of the male upwards to the female. The spermatheca of the latter

is faintly discernible during the act as it swells and collapses. The length of time involving coition in the fleas under observation varied a trifle less than two hours to four and a half hours. The movements preliminary to the act were not noted.

The male makes the first effort to disconnect or disentangle the pair. In one instance, the male attempted to free itself by pressing vigorously the mid and hind tarsi against the hind tibia of its mate. Simultaneously, the antennae were torn from the recumbent spines of the abdominal segments of the female. The abdomen was straightened, relaxing the clutch of the claspers; the spiral contracted releasing the intromittent organ, and a final kick of the hind legs gave the male its liberty. The female was seen on ten distinct occasions to approach the male, and the latter repelled the advances of its larger companion; at each contact of the female, it would jump in the air, attempting to remain on the opposite side of the vial.

Mammalian blood appears essential for fleas to partake of normal functions of copulation and oviposition. In our experience insects kept constantly in jars and reared from cocoons never having been fed upon a host have not been observed to copulate or oviposit. In thirty specimens of *P. irritans* taken from a house which had been vacant for six weeks we found, after three days observation, that the fleas were perfectly healthy; and although females predominated no eggs were found at the end of this period. As a control, six females of this species collected from human hosts when kept in separate vials laid eggs normally, depositing from 5–12 in each instance.

Four experiments with *C. acutus*, the squirrel flea, have given results similar to the foregoing, namely, that this species when reared from cocoons and kept starved in jars at room temperature has not been observed to mate or lay eggs.

In twenty-five paired specimens of several species kept under observation it appears that the male does not long survive the act of mating. It dies even before the female has laid its first batch of eggs. When fertile females are kept under artificial conditions the eggs are laid in one laying in a period beginning two hours after copulation and extending to a maximum of thirty-six hours. When deprived of food the female has never been observed to oviposit after this length of time.

We may note here that when used experimentally the female is invariably longer lived. Experiments to determine length of

life with human blood diet show that female fleas of all species outlive the male by several weeks. This is doubtless true also under natural conditions, where we find in collecting fleas from the host that the females predominate markedly.

The eggs require optimum conditions of temperature and moisture for hatching. They have never been found on the host except in one instance. In this case a dog was used in the laboratory for supplying fresh fleas; this was done by placing the canine on sheets of paper which in a few hours were littered with a large number of flea eggs. These were laid loosely on the host by the fleas, the eggs falling to the paper, where they were collected. Flea eggs have never been found on man, and if present, would not hatch under normal conditions of the body temperature. We have found that keeping eggs in the incubator at blood heat is sufficient to prevent hatching. If the eggs were laid on the host we would certainly expect to find them on the squirrel, on which animal fleas are most abundant. We have taken from two squirrels, respectively, 225 *C. acutus* and 376 of the same species; but in no instance even where fleas are present in such large numbers have we been able to find eggs even after carefully combing the host. The *C. acutus* is by all means the best criterion in this matter, since we have found that it lays more eggs than any other of the rodent fleas.

The eggs are laid singly in small clusters, and may be viscous as in *P. irritans*, *C. fasciatus*, *L. cheopis*, *C. acutus;* or dry as in *C. canis* and *C. musculi*. The former adhere to the medium in which they are laid, and the eggs of the last two species are laid loosely, so that they roll when shaken in the vial containing them.

Eggs may be laid while the insect is still under the influence of an anaesthetic; when covered by a glass slip; and when exposed to strong sun light.

It appears to be the first impulse for the female to lay its eggs when removed from the host and placed under artificial conditions. The great majority of the eggs obtained were laid on the first day, beginning almost immediately after the fleas were captured. It is a common observation that many females with their abdomens distended lay their eggs as soon as the vial is closed over them. The number of eggs laid at one laying by different species, varies from 3 to 18; the rat fleas averaging 6 and the squirrel fleas lay as many as 18.

THE PROCESS OF HATCHING.

C. acutus.

Six eggs laid while the females were kept under observation were examined from time to time until hatched seven to nine days later. One egg, was observed microscopically during the entire process; the other five eggs used as controls were examined occasionally.

On the seventh day of incubation at room temperature the premonitory signs of hatching were discerned in a very faint rising and falling of the exochorion (outer shell layer) on one side of the shell. During the night, seven hours later, the movement grew more extensive, the pulsations becoming quite pronounced, causing the egg to shift slightly from its position. On the morning of the eighth day a deep gash was observed in the side of the egg. The gash is made by the egg opener, a wedge-shaped, horny, claw-like structure on the dorsal side back of the head of the embryo. This is operated so as to hew through the resistant shell by a series of slits or gashes. The initial gash increases slowly in length, encircling the egg within an hour.

In the course of a few hours, seven successive gashes are made, the location of these is quite constant; two on each side of the egg and three at the center, the middle of the latter being the most distinct. The young worm produces these slits through the chorion (inner skin of shell) by turning with its dorsal side against the shell, striking with the egg pick first against the base of the egg, rising on its hind prolegs and striking rapidly as it climbs upwards. Prior to each stroke the egg pick is poised deliberately, the weight of the head accelerating the blow; this is augmented occasionally by a lateral shaking of the head.

When the last slit encircles the shell, the embryo is at the most active stage, it effects a complete rotation in its shell at intervals of ten minutes. The gashes make the shell appear as though cut into ribbons. The rotary movement gradually subsides until a complete turning consumes twenty minutes, and almost imperceptibly there follows a lull. An inactive almost comatose condition prevails for a period of about seventeen hours. After the resting period, it appears that the egg pick is no longer functional; no new gashes are made, the embryo seeming contented to concentrate its energies against the middle gash.

This is enlarged by a puffing and dilating of the head; through the semitransparent shell is seen a constant bubbling and a subsequent dilatation of the cuticle.

On the third day of the hatching process, a strong movement of the embryo gives decided evidence of the progress of hatching. Immediately behind the egg pick, a triangular slit appears through which bubbles emerge to the surface of the exochorion; thus the amnion (the embryonic cuticle) makes its initial appearance through a crack in the exochorion of the shell.

The amnion splits longitudinally adhering to the chorion and bulging out as the insect struggles. It is pushed out of the chorion as the abdominal segments are projecting. The emergence is furthered by the young maggot pressing the head against its tail causing the middle of its body to bulge through the central gap of the shell. The amnion becomes noticeably darker as it is exposed to the air; it is now a light brownish-yellow.

The pressure of the body against the shell forms nearly a round hole through which the larva eventually emerges. The opening is enlarged by pressure of the head against the tail, raising the body like a hoop, causing an arch or a hump to appear with dorsal side outwards.

The amnion sheds slowly on either side from the middle of the arched abdomen ventrally and with a movement of fluid beneath it cracks across the abdomen, peeling and wrinkling as the segments telescope. With a final vigorous bubbling and wrinkling the amnion sheds off, the moulted skin falling on either side, exposing the quite colorless cuticle of the maggot roughly wrinkled and bristling with slender hairs. These hairs which at first appear transparent turn grayish when exposed to the air.

When the tail of the larva has been torn loose from the shell, the head and thorax are still imprisoned within the egg, necessitating a maneuvering by waving its tail in the air, twisting and squirming while standing on its head. The abdomen doubles up ventrally and finally the young larva supported on its tail extricates the head by a violent shaking. When the head is torn from its fastenings, it is found that the amnion has been holding it within the shell. The adhering membrane is cast out when the shell is shaken off. The larva has now fully emerged, the colorless cuticle has turned grayish and the slender threadlike bristles have assumed an iridescent hue.

The larvae upon hatching busy themselves immediately in the quest for food. They experience little difficulty in locating it, for at the time of birth a supply of food is found upon the egg shell. Here they feed from the first on the tiny blood pellicles surrounding the egg shell; this the mother furnishes when the egg is laid. When the last of the egg pellicles of blood are consumed, the insatiable worms look about them for other sustaining morsels. The dejecta of the adult flea seems to provide the desired ingredients. The young larvae feed ravenously on the bloody deposits, apparently satisfied to pass the first few days on this unique diet. They can subsist entirely on the bloody fragments (flea faeces) when no other food is available, for a period of five to six days.

THE REACTION TO LIGHT.

The larva is positively heliotropic up to the stage of the initial moult. The more advanced sluggish larvae are repelled by the light. This is seen when examining the flea breeding cages a slight stirring of the nesting material attracts to the surface the tiny very active larvae. If the older larvae are desired, it is found necessary to nearly invert the container. Prior to the final moult when the larva is in readiness to pupate it can be seen almost invariably along the edges at the bottom of the box, where the greatest number of cocoons are brought to view.

TROPIC INFLUENCES IN THE ADULT FLEAS.

Rodent fleas are negatively phototaxic (repelled by light) to a very striking degree. The first impulse seems to be to seek protection from the light. This is seen in combing a squirrel or rat recently killed; the fleas will retreat constantly to the underside, always in the direction away from the light. When shaken off, they return to the shadow of the host; in numerous instances even when the animal was dead for a period ranging from 24 to 50 hours the fleas when shaken off would seek the host and bury themselves under the hairs away from the light.

When a number of live squirrel fleas and rat fleas were placed in an open test tube and held horizontally with the operator's thumb covering the mouth of the vial and the bottom held against the window, the fleas crowded towards the open mouth in the direction of the thumb, bounding away from the window in an excited manner. When the tube was reversed with the open mouth towards the window, it was found unnecessary to

plug the mouth of the tube as the fleas did not attempt to jump out when given an opportunity to do so. Even when placed within a half inch of the open end of the tube with the head of the insect turned towards the light, the fleas reversed and jumped towards the closed end of the tube. This was repeated by tilting the mouth downward to offer an easier exit through the open mouth; but even this inducement did not influence the fleas, which invariably sought the closed end of the tube in the shadow. This was tried with squirrel and rat fleas as well as with human fleas and always with the same result.

LONGEVITY OF THE CALIFORNIA FLEA.

The great life of our native parasites seems to be anticipated at the very incubation. Eggs are laid at all times. We have observed oviposition during every month. The broods appear to be constant and the number irregular. The incubation stage of our Eastern forms taken from the observations of Pergande consumes 2–4 days ordinarily. Two days is given as the incubation period for the *cheopis* in India. Our experience with this species is a duration varying from 9 to 13 days at room temperature. When eggs of this species were subjected to identical conditions in which wild rats were caged in the laboratory basement (at a temperature of 20° to 25° C.) the length of the egg stage was 19 days.

Larval life is cited by Eastern and English authorities as a minimum of 8 days and a maximum of 24 days. The larval stage of our California fleas under laboratory conditions is never less than 28 days, often 30 days and sometimes longer.

Pergande found that the pupal or cocoon stage of the *Pulex irritans* varied from five to seven days in the summer months at Washington. Other authors working with this species give twelve days during summer months. We have observed several instances of cocoon life during the warm days of September. Thirty days appear to be spent in this stage.

The entire life cycle including adult life is given by several authors as four to six weeks. The British Indian Plague Commission gives as the time necessary for the completion of the cycle of development (in the case of *L. cheopis*) that is from the egg to the imago, as 21 to 22 days.

The following is given as a type of the life cycle observed in *C. acutus*. This specimen was kept under observation from the

moment the egg was laid by its parent. An hour after the egg was laid it was placed in a small vial with a little sawdust, sand, wheat grains and squirrel hair. It was allowed to develop in this environment until matured.

Stage of development	Date	Age of flea
Egg laid	May 4th, 1909	
Hatched	May 12th, 1909	8 days
Moulted (second stage)	May 18th, 1909	14 days
Moulted (third stage)	May 28th, 1909	24 days
Cocoon	June 9th, 1909	36 days
Adult	July 10, 1909	67 days
Alive (never having been fed)	Aug. 11, 1900	99 days

The English workers in India ascertain the length of time which adult fleas live on rats as 41 days. The longest life of this species on an exclusive diet of human blood was observed to be 27 days. We have managed to keep this species (*cheopis*) alive for a period of 36 days by feeding on man. The length of life without feeding was also noted. This period varied in the experiments of the English Commission according to the environments in which the fleas were maintained. In the absence of liquid food supply, fleas could live in bran for six days, in gunny sacking a similar time, and in sand with moist cowdung for 13 days. From our observations we have found the majority of fleas of all species to die in five days unless a moist medium was provided.

As we have stated above rat and squirrel fleas may be kept alive for a considerable time when moisture is provided in some form. It is interesting to note that fleas which have never tasted animal food, having emerged from the cocoon and kept under the same conditions in similar material as fleas taken directly from the host, will prove longer lived. A number of specimens of *Ceratophyllus acutus* removed from a ground squirrel and kept in moistened wheat grains and sawdust lived for 26 days. An equal number of fleas of the same species bred from cocoons in the laboratory were kept without a host in a similar medium. One male lived 38 days and a female lived for 65 days.

In a series of experiments in which fleas taken from healthy rats and squirrels were fed daily on the arm of a man we attempted to determine the maximum longevity of these parasites. The fleas were placed individually in open test tubes and at feeding time the tubes were inverted over the arm of one of the laboratory attendants. Fleas were thus applied daily for a period of from 5 to 15 minutes, but only the actual feeding time was recorded. The average was about five minutes.

A *Loemopsylla cheopis* was fed for 35 days, escaping on the 36th day. One *C. acutus* died after 58 days and another one at the end of 51 days. The common brown rat flea *C. fasciatus*, proved to be the most persistent feeder of them all. Unfortunately one of them was permitted to escape after feeding on its induced host for 63 days. Another of the group suffered no ill effects from its enforced diet for 98 days; and the sole survivor had been nourished by its foster host since its removal from the rodent host for a period of five months. The experiment was discontinued, but the parasite survived a week longer in a starved condition.

LONGEVITY RELATIVE TO SEX.

We have noted the relative longevity of the sexes under the conditions of experiments in which fleas were fed on human blood alone.

We shall take for consideration the two species common to rats, *L. cheopis* and *C. fasciatus* and the predominant squirrel flea, *C. acutus*. Four tests with *C. fasciatus* gave the following data:

C. fasciatus.

Six males of this species averaged 8½ days, the maximum life being 17 days. Fifteen females gave an average of 32 4-5 days with a maximum of 125 days. The two unfed controls (male) of this series lived for 3 days, and the two control females lived for 5 days.

L. cheopis.

Two tests with a total of seven males of this species gave an average of 10 1-7 days and a maximum period of 15 days.

Three females lived 28 1-3 days as an average and a maximum period of 49 days.

The two unfed male controls lived 5 days and in four females the average was 5½ days and the maximum 7 days.

C. acutus.

One test with this species furnishes the following data: Three males averaged 11 days, and gave a maximum of 11 days.

Five females averaged 15 1-5 days. The longest life was 53 days.

The unfed males averaged 3 days and showed a maximum of 4 days. The female control lived 5 days.

The greatest length of life of a male of any species is seen to be 17 days; and the term of life under these conditions for a female was 125 days, somewhat over 4 months.

In these tests for longevity, it should be borne in mind that no attempt is made to arrive at the initial age of the fleas, but the time is reckoned from the day of removal from the host.

An effort was made to determine the length of adult life of one species, *C. acutus*, by feeding the insect newly emerged from the cocoon. Ten specimens emerging within a few hours of each other were fed on the same day on human blood. One specimen, a female, lived for sixty-four days; at which time the experiment was discontinued. The unfed controls, as well as the specimens given a human blood diet, were kept in ordinary test tubes at room temperature. The activities of these fleas may have been influenced by changes in the temperature and the absence of moisture in the tubes.

NOTES ON THE FEEDING PROCESS.

There is a remarkable degree of variation in the feeding habits of the different species of fleas. We have not attempted except in a superficial way, to study the idiocyncracies of the rodent fleas in regard to the biting of their normal hosts. We have, however, quite thoroughly observed the manner of biting under experimental condition with man as a host. Without taking into account the attraction or repulsion which may be exerted towards man as a host, we shall consider the more striking features of the biting of the parasites. We find that the species do not all attack with equal avidity. *Pulex irritans* the ectoparasite of man, is insatiable in its blood craving. It differs in its relation to man in being more fastidious in its feeding than the rodent fleas. Although its bite is painful, it does not voluntarily feed in one spot for any great length of time. The *Pulex irritans* differs from all other species (hundreds of specimens of which were tested on human hosts) in that it squirts blood per anum during the act of biting.

The *L. cheopis* and *C. fasciatus*, the normal rat parasites, are found to bite man with equal readiness and will live about the same length of time when fed on human blood. Their biting is well defined and effective, but not nearly so painful as that of *Pulex irritans*, nor so prolonged as the common squirrel flea, *Ceratophyllus acutus*. A specimen of *C. acutus* when starved for

several days has been observed to feed on man uninterruptedly for a period of nearly one hour (59 minutes) at one insertion of its proboscis.

The bite of the *Ctenopsyllus musculi*, the blind flea of the mouse, is the feeblest we have had inflicted from any flea tested. The short weak piercing organs of this species makes a puncture, which is scarcely perceptible. In observing the length of time this flea bites, it is necessary to depend as a guide on the distention of the abdomen with blood rather than the prick of the mandibles. The *musculi* seems not able to adapt itself as an induced parasite of man. From a few experiments it appears to live not longer than five days on a human host.

The *Ceratopyyllus acutus* which proves a very ready parasite of man makes its attack even without inducing experimentally. Our data compiled from reports and collections of squirrel hunters shows that this species, as well as the other common squirrel flea, *Hoplopsyllus anomalus*, will bite man when exposed to their attacks.

The unusually long rostrum in this flea is presumed to be the cause of its prolonged feeding at one insertion of the mouth parts. This principal is not unprecedented judging from a study of numerous parasites in the insect world.

The following is the description of the method of feeding observed in *C. acutus*. This method is typical.

The flea when permitted to walk freely on the arm selects in a few minutes a suitable hairy space where it ceases abruptly in its locomotion, takes a firm hold, with the tarsi, projects its proboscis and prepares to puncture the skin.

A puncture is drilled by the pricking epipharynx, the saw-tooth mandibles supplementing the movement by lacerating the cavity formed. The two organs of the rostrum work alternately, the middle piece boring, while the two lateral elements execute a sawing movement. The mandibles, owing to their basal attachments are, as is expressed by the Journal of Hygiene, Vol. 6, No. 4, p. 499, "capable of independent action, sliding up and down but maintaining their relative positions and preserving the lumen of the aspiratory channel." The labium doubles back, the V-shaped groove of this organ guiding the mandibles on either side.

The action of the proboscis is executed with a forward movement of the head and a lateral and downward thrust of the entire body. As the mouth parts are sharply inserted, the

abdomen rises simultaneously. The head and middle legs are elevated resembling oars. The fore legs are doubled under the thorax, the tibia and tarsi resting firmly on the epidermis serve as a support for the body during feeding. The maxillary palpi are retracted beneath the head and thorax. The labium continues to bend, at first acting as a sheath for the sawing mandibles, and as these are more deeply inserted, it bends beneath the head with the elasticity of a bow, forcing the mandibles into the wound until the maxillae are embedded in the skin of the victim. When the proboscis is fully inserted, the abdomen ceases for a time its lateral swinging.

The acute pain of biting is first felt when the mandibles have not quite penetrated and subsequently, during each distinct movement of the abdomen. The swinging of the abdomen gradually ceases as it becomes filled with blood. The sting of the biting becomes gradually duller and less sensitive as feeding progresses. The movements of the elevated abdomen grow noticeably feebler as the downward thrusts of the springy bow-like labium become less frequent.

As the feeding process advances, one can discern through the translucent walls of the abdomen, a constant flow of blood, caudally from the pharynx, accompanied by a peristaltic movement.

The end of the meal is signified in an abrupt manner. The flea shakes its entire body, gradually withdraws its proboscis by lowering the abdomen and legs, and violently twisting the head.

When starved for several days, the feeding of the rat fleas is conducted in a rather vigorous manner. As soon as the proboscis is buried to full length, the abdomen is raised and there ensues a gradual lateral swaying motion, increasing the altitude of the raised end of the abdomen until it assumes the perpendicular. The flea is observed at this point to gain a better foothold by advancing the fore tarsi, and, then gradually doubling back the abdomen, it turns a back spring, with extreme agility, nearly touching with its dorsal side the skin of the hand upon which it is feeding. Meanwhile, the hungry parasite feeds ravenously.

It is interesting to note the peculiar nervous action which the rodent fleas exhibit immediately when the feeding process is completed, or when disturbed during the biting. Even while the rostrum is inserted to the fullest, the parasite shakes its head spasmodically, in a twinkling the mouth is withdrawn and the flea hops away.

POSSIBLE VITAL CONSIDERATIONS INVOLVED IN FEEDING HABITS.

We have previously noted that rodent fleas can live in a starved condition, away from the host, during a period of three to ten days, when kept in dry test tubes; as long as twenty-eight days when a suitable moist medium is furnished. The long periods of starvation appear not to affect the vitality of the parasite to such an extent that the ability to feed is impaired. We have recorded instances in which a specimen of the squirrel flea *H. anomalus* starved for sixteen days, and several specimens of *C. acutus* starved for twenty-seven days had sufficient energy to feed 10–15 minutes when an arm was placed in the breeding jar. These facts lead us with others to accredit in a measure the claims of older authorities on plague, who contended before the flea theory was recognized, that clothes and baggage of an infected community harbored the germs of plague, which remain viable during long period of time. Modern writers have called our attention to the plausibility of infection in clothes and baggage due to the agency of fleas, which may be transported from infected communities. Bannerman (Journal of Hygiene, Vol. 6, 1906, pp. 189–191), writing on the possibility of the spread of infection by means of clothes, brings forth several instances in which conveyance of infection by clothes seemed the most likely means of introduction of plague in some villages in India. Plague infected rat fleas secreted in the clothes en route are held responsible for the transmission. Bannerman cites an instance of plague transmission through clothing where as much as ten days elapsed in the transportation of clothing removed from a plague infected victim and worn by a relative of the deceased, who in turn contracted the disease.

It has not been our intention to enter into a discussion of the flea from the standpoint of plague epidemiology; it is desired merely to indicate the possibility that starvation of infected fleas may not eliminate the danger of transmission. The presence of plague bacilli in rodent fleas as pointed out by the English Plague Commission (Journal of Hygiene, Vol. VIII, p. 261) does not appear to affect the rate of mortality in these insects.

SUMMARY OF RESULTS.

1. The breeding of fleas under laboratory conditions can be carried on quite satisfactorily when there is furnished a medium simulating the nest of the host. It will be seen that fleas taken from the natural host can be kept alive without food for a considerable time, providing the proper moisture conditions are maintained. A medium of moist sawdust with a few grains of wheat prolonged the life of these insects to twenty-six days. Those without this medium under the same conditions, died on the seventh day.

2. Rat fleas namely, *L. cheopis*, *C. fasciatus* can not jump higher than 3 1–8 inches.

P. irritans, the human flea, was found to make a perpendicular jump of 7 3–4 inches and as far as 13 inches on a horizontal plane.

3. Experiments with black and white guinea pigs show that in relation to color attraction white animals are no more attractive to the fleas than are the dark colored ones.

4. Experiments with adhesive paper baited with meat, demonstrate that fleas can not be trapped by the odor of meat.

5. In the mating of fleas, the female takes the initiative and the male assumes the passive role.

6. Fleas reared from the cocoon kept without a host have never been observed to copulate or oviposit.

7. The eggs are never laid on the host. Oviposition takes place within thirty-six hours after the female is removed from the host.

8. The process of hatching consumes a period of 3–4 days. The embryo breaks through the shell by means of a special egg pick, which is instrumental in the emergence.

9. The larvae can live on the bloody egg pellicles and the dejecta of the parent for a period of 5–6 days.

10. The larvae are positively heliotropic in the early stages and repelled by light in the later stages.

11. Adult fleas are negatively phototaxic.

12. The California rodent fleas have a greater life in all stages than fleas of the Eastern United States and India. The

average length of the stages of development, in *C. acutus* as a type, are as follows:

Egg stage	8 days
Larval stage	28 days
Cocoon	31 days
Adult without host	32 days and longer

13. Fleas which have never been fed from the time of emergence from the cocoon prove longer lived when starved than fleas removed from the host.

14. Rat fleas may be kept alive on a human host for a considerable time, one specimen being kept alive as long as five months.

15. The females of all species of fleas are considerably longer lived than the males.

16. Induced parasitism of rodent fleas on man seems to be influenced by the length of mouth parts in the different species. One specimen of *C. acutus*, the species with the longest rostrum, fed for a period of nearly one hour at one insertion of the mouth.

17. It is indicated that starvation of infected fleas, when these insects are transported in clothing, may not eliminate the danger of transmission of plague.

NOTICE TO MEMBERS AND CONTRIBUTORS.

The Annals of the Entomological Society of America will be published by the Society quarterly and will include the Proceedings of the Annual meetings and such papers as may be selected by the Editorial Board.

Papers may be submitted to any member of the Editorial Board and should be as nearly as possible in the form desired as final, preferably typewritten, and illustrations must be finished complete ready for reproduction. Plates must not exceed 5 x 7 inches unless intended to fold. In general, papers to be accepted must be original, complete and previously unpublished and, except in connection with the proceedings, it will not be the policy to publish preliminary announcements or notes. Authors will be allowed fifty reprints gratis and additional copies at cost to the Society.

The annual subscription to members is $1.00 in addition to the annual dues and may be sent to the Secretary-Treasurer. Mr. J. Chester Bradley, Cornell University, Ithaca, N. Y.

Communications relating to the Annals, and all orders for separate copies or reprints should be addressed to the Managing Editor or to ANNALS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA, Biological Building, O. S. U., Columbus, Ohio.

CONTENTS OF THIS NUMBER.

BRADLEY, J. C.—Minutes of the Boston Meeting..... 1

SMITH, J. B.—Abstract of Address, Entomology and Entomologists..... 12

WEBSTER, F. M.—A Predaceous and Supposedly Beneficial Mite, Pediculoides, Becomes Noxious to Man..... 15

BANKS, NATHAN.—Myrmeleonidae from Australia..... 40

WILLIAMS, FRANCIS X.—The Anatomy of the Larva of Cecidomyia Resinicoloides Williams..... 45

MITZMAIN, M. B.—Some New Facts in the Bionomics of the California Rodent Fleas..... 61

The regular annual subscription price for the ANNALS is, in the United States, Cuba, Porto Rico, Hawaii and Mexico, $3.00; Canada, $3.50, other countries, $4.00. Checks, drafts or money orders should be drawn payable to ANNALS ENTOMOLOGICAL SOCIETY OF AMERICA, and addressed to Biological Building, O. S. U., Columbus, Ohio, U. S. A.